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Video Landing Parameter Survey—Washington National Airport

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16. Abstract

The Federal Aviation Administration William J. Hughes Technical Center is conducting a series of video landing parameter surveys at high-capacity commercial airports to acquire a better understanding of typical contact conditions for a wide variety of aircraft and airports as they relate to current aircraft design criteria and practices.

This was the second in a ongoing series of parameter landing surveys and was conducted at Washington National Airport in June 1995. Four video cameras were temporarily installed along the east side of runway 36. Video images of 532 transport, (525 narrow-body jets and 7 commuter jets) were captured, analyzed, and the results presented herein. Landing parameters presented include sink rate; approach speed; touchdown pitch, roll, and yaw angles; off-center distance; and the touchdown distance from the runway threshold measured along the runway center line. Wind and weather conditions were also recorded and landing weights were available for most landings. Since this program is only concerned with the overall statistical usage information, all data were processed and are presented without regard to the airline or the flight number.

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EXECUTIVE SUMMARY

The Federal Aviation Administration (FAA) William J. Hughes Technical Center is conducting a series of video landing parameter surveys at high-activity commercial airports to acquire a better understanding of typical landing contact conditions for a wide variety of aircraft and airports as they relate to current aircraft design criteria and practices.

This is the second of a series of landing parameter surveys. This report documents the results from a survey at Washington National Airport (DCA), performed in June 1995. The initial survey was conducted at John F. Kennedy International Airport (JFK) in June 1994. At Washington National Airport, four video cameras were temporarily installed along the east side of runway 36. Video images of 532 transports (525 narrow-body jet transports, and 7 commuter jet aircraft) were captured, analyzed, and the results presented herein. Landing parameters presented include sink rate; approach speed; touchdown pitch, roll, and yaw angles; off-center distance; and the touchdown distance from the runway threshold. Wind and weather conditions were also recorded and landing weights were available for most landings. Since this program is only concerned with overall statistical usage information, all data were processed and are presented without regard to the airline or flight number.

This survey has reinforced the findings from the JFK survey concerning the landing impact parameters of narrow-body jet aircraft. The results from these two surveys differ substantially from aircraft sink speeds reported 35 years ago during National Aeronautics and Space Administration (NASA) surveys. No other efforts to collect operational landing data were performed by either the FAA or NASA in the interim.

1. INTRODUCTION.

In an effort to better understand and document the actual operational environment of commercial jet transport aircraft landing impact conditions, the Federal Aviation Administration (FAA) William J. Hughes Technical Center initiated a series of aircraft video landing parameter surveys at high-activity commercial airports. By collecting and analyzing large quantities of video data for a wide variety of aircraft, the original design criteria and fatigue-life estimates for aircraft landing gear and support structures can be assessed and verified. This operational data will also aid in developing design requirements for future jet transports.

The use of image data to evaluate the landing performance of aircraft has been used since jet aircraft were introduced. In 1947 [1], the US Navy first developed a system to characterize the typical carrier landing environment and implemented procedures to make carrier arrested landings safer. The Navy system acquired aircraft landing and approach data from the tracking and analysis of recorded 16-mm film images of the arrestment. In 1954, the National Aeronautics and Space Administration (NASA) developed a similar system using a 35-mm camera and conducted a number of surveys of commercial airplanes, the last ones in 1959 [2-7]. The difference between the two systems was that the Navy photographed from a head-on aspect along the runway apron, while NASA's camera was positioned perpendicular to the runway, approximately 900 feet from the runway center line.

In 1967, the Navy enhanced its system by replacing the 16-mm cameras with 70-mm cameras. This provided considerably greater image resolution and consequently greater accuracy [8]. Using this system, the Navy conducted over 40 landing parameter surveys. However, the data reduction phase of the research was labor intensive and limited the number of surveys which could be conducted. The search for a new improved system was concluded in 1992 when the Navy successfully developed and implemented a system that uses adaptive video imaging and tracking technology for their surveys. The performance and accuracy of this system is documented in references 9 and 10. Shortly thereafter, the FAA and the Navy established an interagency agreement to transition this newly developed video technology to commercial operations [11].

Preliminary results from this work were presented at the 1995 ICAF Symposium [12], the 1995 FAA Airports Conference [13], the 1995 International Society of Air Safety Investigators Conference [14], and the 1995 USAF ASIP Conference [15].

The objectives of the FAA landing parameter survey program are to acquire large amounts of typical transport operational data to (1) validate and update NASA TN D 4529 which was derived from usage data measured during the 1950s, (2) to provide detailed characterization of typical transport airplane landing velocities and angular displacements, and (3) to determine if there is a trend towards higher sink rates at higher gross weights.

The first of the FAA's commercial aircraft video landing surveys was conducted in 1994 at John F. Kennedy International Airport (JFK), runway 13L, in New York to collect large quantities of wide-body jet aircraft data [16].

The second survey performed at Washington National Airport collected landing parameters for flight operations using a shorter runway. The principle runway (runway 36) at Washington National Airport is 7000 ft long and cannot handle aircraft larger than the Airbus A-320 and the Boeing 757. In addition, since prior NASA surveys collected only data from narrow-body B-707 and DC-8 airplanes, this would allow a comparison with the previous NASA results. Data from this survey should be useful in the design and certification of narrow-body transport aircraft.

Video images of aircraft landing on runway 36 were recorded by a series of four cameras temporarily installed on the edge of the runway. Runway 36 was selected for this survey since it is the only runway at Washington National Airport equipped with an Instrument Landing System (ILS). The data were collected on runway 36 over a 2-week period in June 1995. These video images were stored on an optical disk recorder, processed, and analyzed at the Naval Air Warfare Center, and the resulting landing parameter information was forwarded to the William J. Hughes Technical Center.

Since the primary goal of this survey was to collect statistical information on actual operations, the identity of individual aircraft, airlines, flight numbers, and dates were purposefully omitted from this report. Aircraft landing performance was analyzed only on the basis of aircraft category, model, type, and wind conditions.

2. SYSTEM DESCRIPTION.

Modern developments in video technology have permitted the Navy to transition its landing parameter data analysis system from using photographic film to one using video technology. The Navy video system is known as the Naval Aircraft Approach and Landing Data Acquisition System (NAALDAS). The system consists of a high-resolution frame grab video camera, a laser disk recorder, and a computer control unit. The key to the NAALDAS system is a highly modified video camera. The camera's enhanced vertical resolution (double that of standard video formats) permits highly accurate measurement and tracking of aircraft position data. The camera is supported by an image analysis system using image processing technology. Particular image features (landing gear wheels, wing tips, flaps, or engine inlets) are tracked in successive images, and this information is used to determine the relative motion of the aircraft. The combination of camera resolution and image processing technology permits the location of image features to be determined within 0.1 pixel. This technique is as accurate, but more efficient than the Navy's previously used 70-mm film system.

NAALDAS was designed to cover the restricted touchdown area on an aircraft carrier using a single camera. To support the commercial application, the FAA funded the design and development of a modified, multiple-camera configuration of NAALDAS using four video cameras located along the edge of the runway. The images from these cameras are recorded sequentially as the aircraft passes through their field of view. This modification expands the system coverage area to approximately 2000 ft along the anticipated touchdown region of the runway. Fiber-optic signal cables are used to eliminate interference and line losses between the cameras and the recording station. The modified configuration of NAALDAS was successfully

tested in February 1994 at the William J. Hughes Technical Center, Atlantic City International Airport (ACY), New Jersey. Figure 1 shows a camera in operation on a commercial runway.

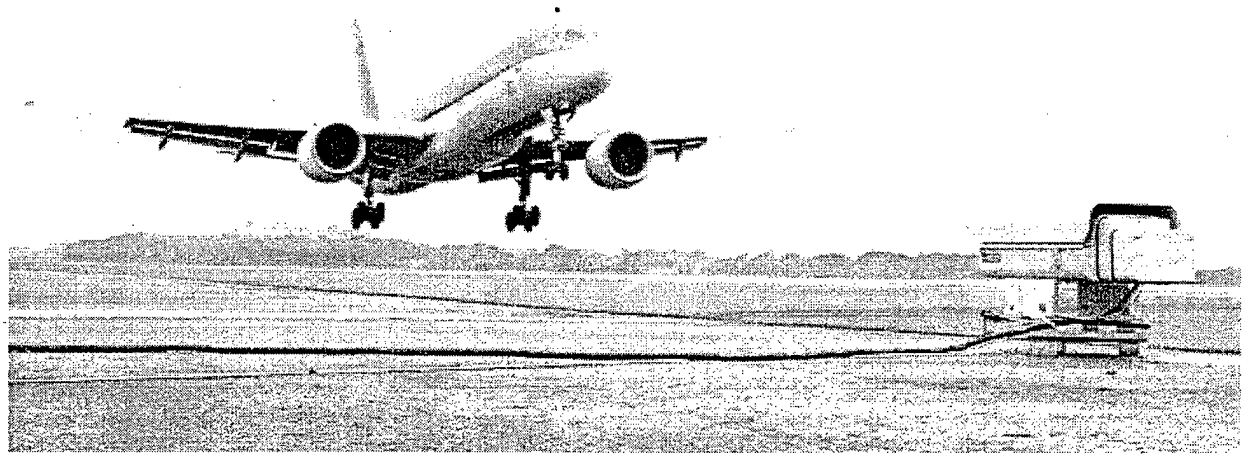

FIGURE 1. VIDEO CAMERA IN OPERATION DURING COMMERCIAL LANDING PARAMETER SURVEY

The video cameras are installed on the edge of the runway, usually facing toward the approaching aircraft. The cameras are located approximately 475 feet apart, starting 800 feet from the end of the runway, and usually located in line with the runway edge lights, which at Washington National Airport are approximately 110 ft off the runway center line. The camera is aimed at the center of the targeted touchdown area. The camera's aim is fixed and does not track the aircraft. Figure 2 is a schematic of the multiple camera configuration. Because of the location of a runway intersection 1750 feet from the runway 36 threshold at Washington National Airport, one camera was oriented toward the runway 18 end and recorded data from a rear view of the aircraft. Less than 20 landings from this survey were processed from this rear view camera.

The NAALDAS video cameras have a fixed field of view. Each camera is aligned and calibrated against temporary alignment targets which are placed on the runway for that purpose. These targets are placed in surveyed locations, and the target images are recorded as a calibration sequence. This sequence is processed to generate a transformation matrix to relate image measurements to the runway.

The NAALDAS data recording system is operated from a vehicle parked in a safe location near the touchdown region of the survey runway. Judicious selection of this parking location is required to prevent any interference with airport operations. At Washington National Airport, this location was 350 ft from the runway center line. Temporary cabling is run from the vehicle to the cameras and the vehicle remains in the chosen location during flight operations. The system is powered entirely with portable electrical generators. Currently NAALDAS is limited to coverage of one end of a runway and cannot be relocated to accommodate runway changes.

This restriction exists since the cameras must be precisely aimed and recalibrated if they are relocated, which requires the runway be closed.

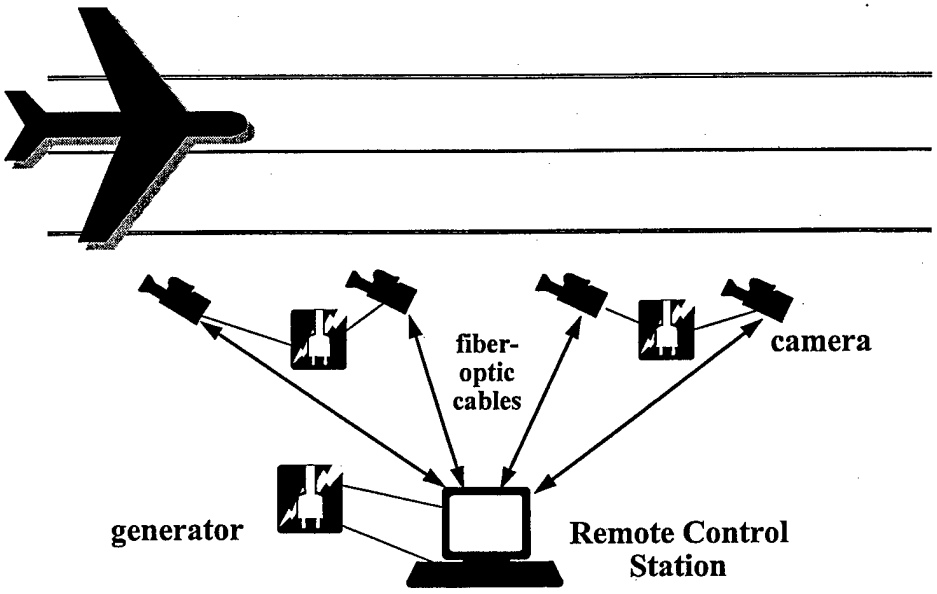

FIGURE 2. FAA LANDING LOADS CAMERA SETUP

The aircraft image is captured on an optical laser disk recorder for subsequent analysis on the NAALDAS analysis system work station. Approximately 60 landings can be stored on a disk. An identity number is assigned to the disk, and event numbers are assigned to each video sequence. The use of video disks eliminates film processing cost and time.

Image enhancement and automatic data point tracking are performed using the analysis work station. This provides position time information of image features on the aircraft. Each individual airplane landing is also identified by model type and serial number so that the necessary physical dimensions and geometric locations can be correlated with the time-tracked video images. The software data reduction system then derives the landing impact parameters, i.e., sinking speed, horizontal velocity, bank angle, crab angle, etc.

The analysis station consists of a Sun computer work station with an image processing board, laser disk player, computer monitor, high-resolution monitor, and associated power regulator and cables. The station operator automatically tracks the video image features during the landing sequence. By positioning windows over the desired image feature, the operator prepares the system to track that feature through the entire sequence. Multiple-image features can be tracked simultaneously using multiple windows. The operator has the capability to select image threshold levels, image enhancement formats, and algorithms. The operator can also select the type of tracking (edge or centroid) to be used. These selections allow the system to automatically track the image, eliminating the errors in data reduction which were inherent in the manual

tracking procedures used with the 70-mm film system. The centroid tracking algorithm enables the system to locate image features with subpixel accuracy.

Once the image sequence is tracked, the pixel information is transformed, digitized, and entered into the landing parameter analysis software. This software takes image position information, determines the change in image feature position of successive frames at a rate of 30 frames per second, and generates position time curves for the feature.

In addition to the video images, from which the ground contact parameters are derived, other data describing each landing are collected during the video survey to determine which set of geometric data to use in the analysis. An anemometer, temporarily installed near the survey site, collected wind speed and direction for each landing. An estimate of the aircraft's touchdown landing weight was provided by the aircraft operators.

3. DISCUSSION.

3.1 WASHINGTON NATIONAL AIRPORT DATA SUMMARY.

Video images from a total of 532 landings from the survey at Washington National Airport (DCA) were processed. A total of 525 jet transport aircraft landings were analyzed, along with seven landings of the Canadair Regional Jet transport.

The video landing survey data acquisition equipment was installed on the east side of runway 36, a 150-foot-wide, 7,000-foot-long runway. This runway was selected after reviewing historical landing runway operations data and determining that suitable camera positions were available. Once the survey cameras are installed and calibrated, they cannot be moved to adjust to changes in operation caused by wind shifts. During much of the survey the winds frequently favored operations on the other end of the runway. However, since runway 36 was the only Washington National Airport runway equipped with an ILS for operations in low-visibility conditions, landings were performed on runway 36 even with adverse wind conditions.

Although there were a significant number of commuter aircraft landings at the airport, a statistically significant number of commuter landings were not recorded. The airports other two runways were used solely for commuters. The commuter terminal at Washington National Airport is located at the North End of the terminal complex. Commuter aircraft landing on runway 36 would descend to within a few feet of touchdown and then maintain that altitude until beyond the coverage area of our cameras. We believe this was done to reduce the time needed to taxi to the terminal. Similarly, since the main terminal is located at the center of the terminal complex, there was an incentive for the jet transports to touchdown as close as practical to the runway threshold to exit the runway as near as possible to the terminal. This may contribute to the sink speed distribution observed.

The analysis of image data provides the aircraft's closure speed with respect to the camera. The reported value of approach speed is the sum of closure speed and the component of wind parallel to the center line of the runway. The wind speed and direction information measured using an anemometer situated near the touchdown location was used to calculate the approach speed.

Landing parameters for 525 narrow-body transports and 7 commuter jet landings were calculated using the procedures described in references 8 and 10. Table 1 summarizes the primary landing parameters for the ten model types covered in this survey. The table provides the mean and standard deviation and the number of observations for selected landing parameters. More detailed summaries are provided in appendix A. Scatter plots of aircraft sink speed versus landing weight and approach speed versus landing weight are presented in figures 3 and 4. The values of landing parameters determined for individual landings in the survey are provided in appendix B. Landing parameter survey definitions in appendix C provide an explanation of the symbols and definition of parameters used in this report.

TABLE 1. SURVEY PARAMETER COMPARISON BY AIRCRAFT MODEL

NARROW-BODY JET TRANSPORTS									
Aircraft Model	Number of Events		Closure Speed	Approach Speed	Sink Speed	Pitch Angle	Roll Angle	Yaw Angle	Runway Off-Center Distance
A-320	26	Mean	135.4	137.4	3.07	6.63	-1.3	-4.19	1.81
		Std. Dev.	9.47	9.02	2.22	1.13	2.75	4.91	5.65
B-727	106	Mean	137.3	139.4	2.33	5.31	-0.38	-3.38	3.37
		Std. Dev.	11.01	10.98	1.82	1.43	2.89	4.71	5.62
B-737-100	120	Mean	137.3	139.5	2.2	5.36	-0.77	-2.28	3.79
		Std. Dev.	10.34	10.12	1.54	1.8	2.82	4.28	4.02
B-737-300	8	Mean	141	142.9	2.82	5.91	-1.71	-4.44	0.25
		Std. Dev.	12.2	12.4	1.59	1.55	2.32	4.71	7.01
B-757	60	Mean	129.3	131.5	2.56	6.2	-0.8	-3.03	3.73
		Std. Dev.	8.16	7.48	1.82	1.12	2.52	4.71	6.66
DC-9	70	Mean	132.5	134.8	2.43	4.88	-1.19	-2.25	4.33
		Std. Dev.	9.89	9.42	1.5	1.19	2.27	4.91	4.42
F-28	3	Mean	121	123	2.54	5.00	-2.83	-0.93	2.0
		Std. Dev.	3.02	3.91	1.12	1.98	5.77	8.79	1.63
F-100	14	Mean	123.2	125.5	2.31	4.11	-0.97	-2.09	4.43
		Std. Dev.	15.09	15.1	1.55	0.8	4.06	5.12	5.32
MD-80	118	Mean	137.2	139.4	2.57	5.3	-0.45	-3.78	2.86
		Std. Dev.	10.33	10.14	1.57	1.4	3.99	5.22	4.39
REGIONAL JET TRANSPORTS									
Canadair RJ	7	Mean	128	129.8	3.62	3.21	-1.17	-3.29	2.14
		Std. Dev.	15.7	15.43	2.16	2.27	2.37	5.77	3.27

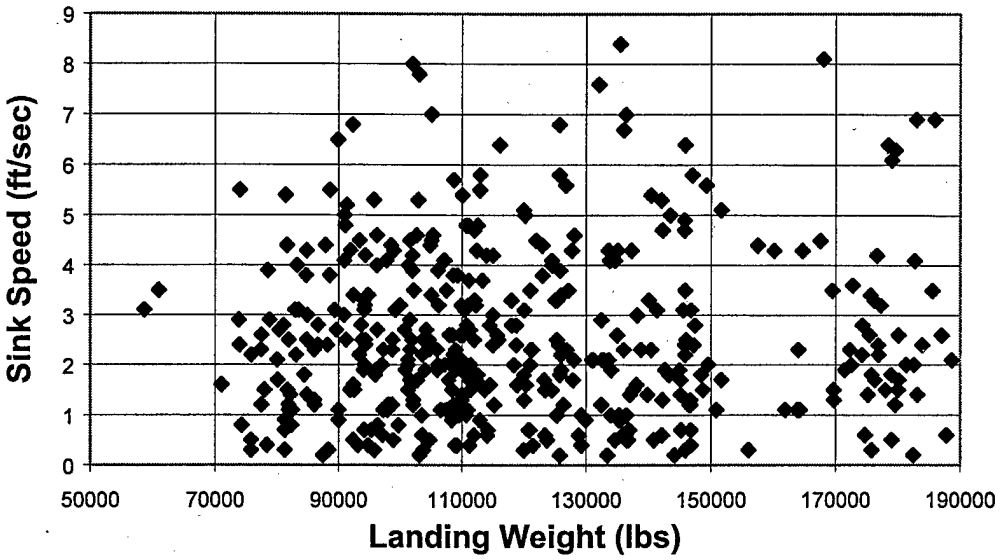

FIGURE 3. AVERAGE MAIN WHEEL SINK SPEED VERSUS LANDING WEIGHT, ALL JET TRANSPORTS

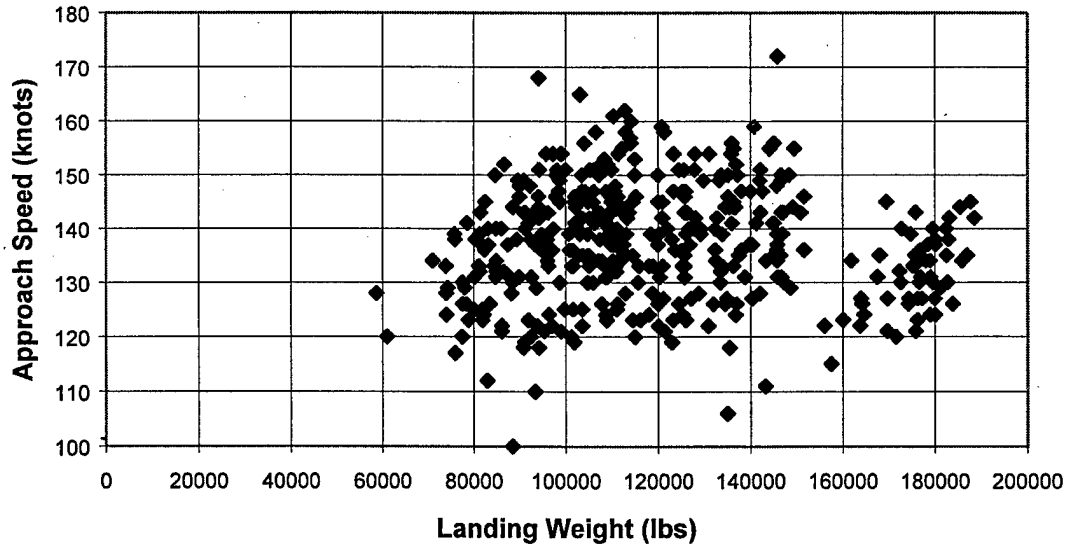

FIGURE 4. APPROACH SPEED VERSUS LANDING WEIGHT, ALL JET TRANSPORTS

3.2 COMPARISON OF WASHINGTON NATIONAL AIRPORT RESULTS WITH JOHN F. KENNEDY (JFK) INTERNATIONAL AIRPORT RESULTS.

A comparison of the results obtained from this survey and the previous results obtained at the John F. Kennedy International Airport (JFK) in New York is presented in table 2. The number of aircraft models available for direct comparison is somewhat limited since the survey at Washington National Airport did not include any wide-body jets, which were one of the primary areas of interest for the JFK International Airport survey. In addition, no A-320 landings were recorded at JFK. This left five narrow-body jet models for comparison, although the number of Boeing 737 aircraft recorded at JFK was extremely small.

TABLE 2. COMPARISON OF LANDING SURVEY RESULTS

		Washington National Airport Survey		John F. Kennedy Airport Survey	
Aircraft Model		Approach Speed Summary	Average Sink Speed Summary	Approach Speed Summary	Average Sink Speed Summary
Boeing 727	Mean	139.4	2.33	139.7	2.25
	Standard Deviation	10.98	1.82	7.75	1.53
	No. of landings	106	106	84	84
Boeing 757	Mean	131.5	2.56	130.5	2.01
	Standard Deviation	7.48	1.82	10.27	1.46
	No. of landings	60	60	79	79
DC-9	Mean	134.8	2.43	138.2	2.22
	Standard Deviation	9.42	1.5	9.37	1.85
	No. of landings	70	70	42	42
MD-80	Mean	139.4	2.57	137.2	2.11
	Standard Deviation	10.14	1.57	11.09	1.56
	No. of landings	118	118	36	36

The sample size for any one model type is not sufficient to conduct any meaningful comparison or draw conclusions regarding the sink rate and approach velocity of each aircraft model. The apparent differences in mean values and standard deviation of table 2 may result from the difference in runway length (9000 ft at JFK and 7000 ft at Washington National) and approach patterns at the two airports.

An unexpected number of high sink speed landings were observed during this survey. While aircraft sink speeds of 10 ft/sec are frequently observed during carrier operations, it was anticipated that landings in excess of 4 ft/sec would be rather rare in commercial operations. The results of this survey have identified 103 landings (almost 20%) which had sink speeds of 4 ft/sec or more and 3 landings were between 8 and 9 ft/sec. In comparison, 90 landings with sink speeds in excess of 4 ft/sec were measured during the JFK International Airport survey (15%). The JFK survey measured six landings in excess of 8.0 ft/sec, four narrow- and two wide-body jets. The design limit descent velocity for commercial transports is 10 ft/sec [17], and

14 CFR 25, Aeronautics and Space, Airworthiness Standards: Transport Category Airplanes, considers this a once per lifetime event. The 14 CFR 25 does not specify a sink speed frequency distribution. The military specification MIL-A-8866 for similar aircraft assumes a 10-ft/sec landing occurs once every 2000 landings and a 9-ft/sec landing once every 1000 landings.

Figure 5 provides a histogram of the sink speed distribution recorded during this survey.

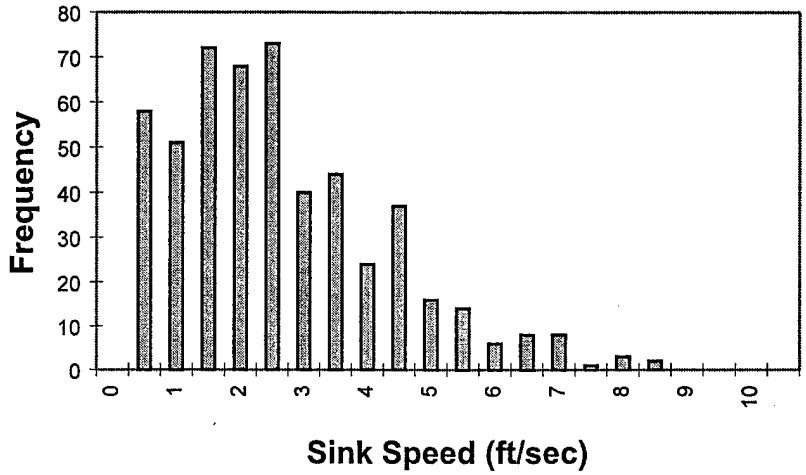

FIGURE 5. HISTOGRAM OF JET TRANSPORT AIRCRAFT SINK SPEED, WASHINGTON NATIONAL AIRPORT SURVEY

Since there is no equivalent commercial specification, the observed sink speed distributions from the Washington National Airport and JFK International Airport surveys were compared with the distributions from MIL-A-8866. Commercial manufacturers estimate the anticipated usage of the aircraft during the airplanes design phase. Figure 6 is a plot of the probability that an aircraft's sink speed would reach a particular value. The military specifications are identified as the MIL-A-8866 curve. Separate curves are included for narrow-body aircraft from the Washington National Airport and JFK International Airport surveys.

3.3 COMPARISON WITH PRIOR NASA RESULTS.

The early NASA photographic landing surveys [3-6] were conducted in the late 1950's and early 1960's to determine whether a significant difference existed between the sink rates of narrow-body jet airplanes and piston engine transports. These studies determined that the jet airplanes did have sink speeds greater than the piston transports, however since these values averaged well below 2 ft/sec, the continued use of a 10-ft/sec design value was considered to be appropriate.

The data collected in the JFK International Airport and Washington National Airport surveys show sink rates considerably greater than those from the prior NASA research. These new findings are of considerable concern to both the FAA and industry, so much so that a joint FAA and industry research team has been established to independently check system accuracy and to determine the exact cause of these differences.

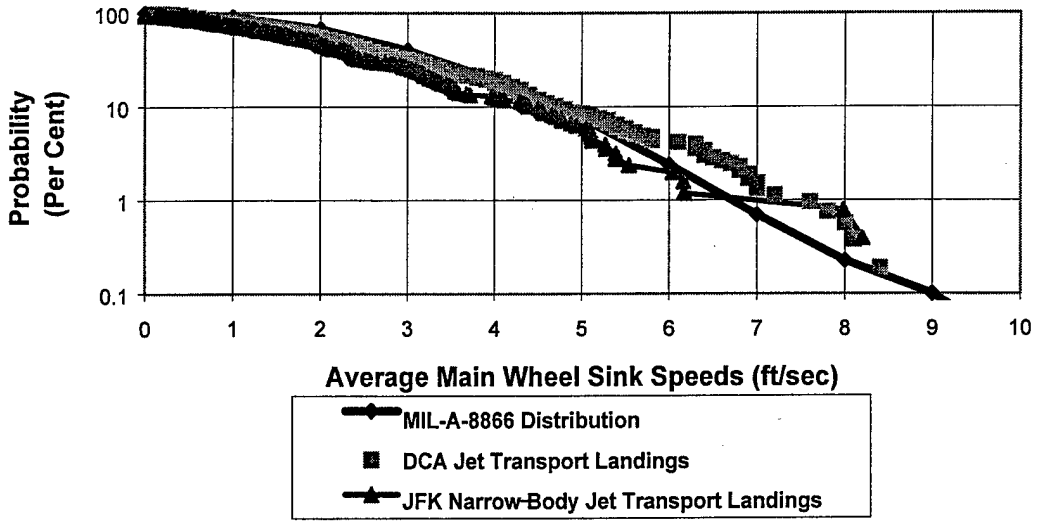

FIGURE 6. PROBABILITY DISTRIBUTION OF FAA LANDING SURVEY SINK SPEED COMPARISON

4. CONCLUDING REMARKS.

This research is part of a continuing effort to conduct a series of landing parameter surveys intended to assess current design and regulatory requirements for aircraft landing gear and support structure. Results of this survey are as follows.

- The video landing data acquisition system has been shown to be a practical, cost-effective technique for collecting large quantities of typical landing parameter data at a major commercial airport.
- The survey results have been consistent, the two surveys demonstrated comparable results for similar aircraft models.
- The sink speed distributions resulting from these FAA surveys are greater than those found in previous NASA work. The volume and intensity of current flight operations may contribute to this variation.
- Due to the dispersion of landing parameters, an analysis of weather effects on landing parameters should be undertaken during subsequent surveys.
- Additional survey data are needed to properly assess current regulatory requirements.

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APPENDIX A—STATISTICAL DATA FOR FAA LANDING PARAMETERS SURVEY DATA SUMMARY BY MODEL AT WASHINGTON NATIONAL AIRPORT

AIRCRAFT MODEL AIRBUS A-320

Parameter	Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sinking Speed: Port Wheel	2.84	2.24	ft/sec	26
Starboard Wheel	3.19	2.3	ft/sec	26
Average of Main Wheels	3.07	2.22	ft/sec	26
Closure Speed (Measured to Camera)	135.4	9.47	knots	26
Approach Speed	137.4	9.02	knots	26
Wind Speed: Parallel Component	2.08	2.69	knots	26
Perpendicular Component	5.23	3.38	knots	26
Pitch Angle at Touchdown	6.63	1.13	degrees	26
Roll Angle at Touchdown	-1.3	2.75	degrees	26
Yaw Angle at Touchdown	-4.19	4.91	degrees	26
Calculated Glide Slope Angle	0.77	0.55	degrees	26
Distance From Touchdown to Runway Threshold	1099	218	feet	26
Off Center Distance at Touchdown	1.81	5.65	feet	26
Aircraft Reported Landing Weight	126669	7221	pounds	24

AIRCRAFT MODEL BOEING 727

Parameter	Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sinking Speed: Port Wheel	2.2	2.03	ft/sec	106
Starboard Wheel	2.45	1.91	ft/sec	106
Average of Main Wheels	2.33	1.82	ft/sec	106
Closure Speed (Measured to Camera)	137.2	11.01	knots	106
Approach Speed	139.4	10.98	knots	106
Wind Speed: Parallel Component	2.18	2.58	knots	106
Perpendicular Component	5.43	3.27	knots	106
Pitch Angle at Touchdown	5.31	1.43	degrees	106
Roll Angle at Touchdown	-0.38	2.89	degrees	106
Yaw Angle at Touchdown	-3.38	4.71	degrees	106
Calculated Glide Slope Angle	0.58	0.47	degrees	106
Distance From Touchdown to Runway Threshold	1192	306	feet	106
Off Center Distance at Touchdown	3.37	5.62	feet	106
Aircraft Reported Landing Weight	140857	9096	pounds	71

AIRCRAFT MODEL BOEING 737-100/200

Parameter	Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sinking Speed: Port Wheel	2.02	1.58	ft/sec	120
Starboard Wheel	2.23	1.71	ft/sec	120
Average of Main Wheels	2.2	1.54	ft/sec	120
Closure Speed (Measured to Camera)	137.3	10.34	knots	120
Approach Speed	139.5	10.12	knots	120
Wind Speed: Parallel Component	2.23	2.54	knots	120
Perpendicular Component	6.18	3.54	knots	120
Pitch Angle at Touchdown	5.36	1.8	degrees	120
Roll Angle at Touchdown	-0.77	2.82	degrees	120
Yaw Angle at Touchdown	-2.28	4.28	degrees	120
Calculated Glide Slope Angle	0.55	0.38	degrees	120
Distance From Touchdown to Runway Threshold	1104	198	feet	120
Off Center Distance at Touchdown	3.79	4.02	feet	120
Aircraft Reported Landing Weight	101696	8657	pounds	97

AIRCRAFT MODEL BOEING 737-300/400/500

Parameter	Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sinking Speed: Port Wheel	2.65	1.75	ft/sec	8
Starboard Wheel	2.91	1.57	ft/sec	8
Average of Main Wheels	2.82	1.59	ft/sec	8
Closure Speed (Measured to Camera)	141	12.2	knots	8
Approach Speed	142.9	12.4	knots	8
Wind Speed: Parallel Component	1.99	2.96	knots	8
Perpendicular Component	4.25	3.65	knots	8
Pitch Angle at Touchdown	5.91	1.55	degrees	8
Roll Angle at Touchdown	-1.71	2.32	degrees	8
Yaw Angle at Touchdown	-4.44	4.71	degrees	8
Calculated Glide Slope Angle	0.71	0.45	degrees	8
Distance From Touchdown to Runway Threshold	1273	459	feet	8
Off Center Distance at Touchdown	0.25	7.01	feet	8
Aircraft Reported Landing Weight	107556	6808	pounds	5

AIRCRAFT MODEL BOEING 757

Parameter	Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sinking Speed: Port Wheel	2.34	1.94	ft/sec	60
Starboard Wheel	2.74	1.99	ft/sec	60
Average of Main Wheels	2.56	1.82	ft/sec	60
Closure Speed (Measured to Camera)	129.3	8.16	knots	60
Approach Speed	131.5	7.48	knots	60
Wind Speed: Parallel Component	2.21	2.13	knots	60
Perpendicular Component	5.45	3.16	knots	60
Pitch Angle at Touchdown	6.2	1.12	degrees	60
Roll Angle at Touchdown	-0.8	2.52	degrees	60
Yaw Angle at Touchdown	-3.03	4.71	degrees	60
Calculated Glide Slope Angle	0.67	0.47	degrees	60
Distance From Touchdown to Runway Threshold	1144	296	feet	60
Off Center Distance at Touchdown	3.73	6.66	feet	60
Aircraft Reported Landing Weight	175306	7614	pounds	53

AIRCRAFT MODEL CANADAIR REGIONAL JET

Parameter	Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sinking Speed: Port Wheel	3.24	2.12	ft/sec	7
Starboard Wheel	3.6	2.1	ft/sec	7
Average of Main Wheels	3.62	2.16	ft/sec	7
Closure Speed (Measured to Camera)	128	15.71	knots	7
Approach Speed	129.8	15.43	knots	7
Wind Speed: Parallel Component	1.87	2.08	knots	7
Perpendicular Component	6	1.41	knots	7
Pitch Angle at Touchdown	3.21	2.27	degrees	7
Roll Angle at Touchdown	-1.17	2.37	degrees	7
Yaw Angle at Touchdown	-3.29	5.77	degrees	7
Calculated Glide Slope Angle	0.95	0.49	degrees	7
Distance From Touchdown to Runway Threshold	987	231	feet	7
Off Center Distance at Touchdown	2.14	3.27	feet	7
Aircraft Reported Landing Weight			pounds	

AIRCRAFT MODEL McDONNELL DOUGLAS DC-9

Parameter	Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sinking Speed: Port Wheel	2.45	1.74	ft/sec	70
Starboard Wheel	2.36	1.53	ft/sec	70
Average of Main Wheels	2.43	1.5	ft/sec	70
Closure Speed (Measured to Camera)	132.5	9.89	knots	70
Approach Speed	134.8	9.42	knots	70
Wind Speed: Parallel Component	2.35	2.27	knots	70
Perpendicular Component	6.47	3.31	knots	70
Pitch Angle at Touchdown	4.88	1.19	degrees	70
Roll Angle at Touchdown	-1.19	2.27	degrees	70
Yaw Angle at Touchdown	-2.25	4.91	degrees	70
Calculated Glide Slope Angle	0.62	0.37	degrees	70
Distance From Touchdown to Runway Threshold	1111	194	feet	70
Off Center Distance at Touchdown	4.33	4.42	feet	70
Aircraft Reported Landing Weight	90197	13713	pounds	59

AIRCRAFT MODEL FOKKER F-28

Parameter	Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sinking Speed: Port Wheel	2.59	0.89	ft/sec	3
Starboard Wheel	1.89	1.33	ft/sec	3
Average of Main Wheels	2.54	1.12	ft/sec	3
Closure Speed (Measured to Camera)	121	3.02	knots	3
Approach Speed	123	3.91	knots	3
Wind Speed: Parallel Component	1.96	1.46	knots	3
Perpendicular Component	7.5	1	knots	3
Pitch Angle at Touchdown	5	1.98	degrees	3
Roll Angle at Touchdown	-0.9	3.43	degrees	3
Yaw Angle at Touchdown	-0.93	8.79	degrees	3
Calculated Glide Slope Angle	0.71	0.32	degrees	3
Distance From Touchdown to Runway Threshold	986	204	feet	3
Off Center Distance at Touchdown	2	1.63	feet	3
Aircraft Reported Landing Weight	59763	1167	pounds	2

AIRCRAFT MODEL FOKKER F-100

Parameter	Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sinking Speed: Port Wheel	2.19	1.62	ft/sec	14
Starboard Wheel	2.42	1.59	ft/sec	14
Average of Main Wheels	2.31	1.55	ft/sec	14
Closure Speed (Measured to Camera)	123.2	15.09	knots	14
Approach Speed	125.5	15.1	knots	14
Wind Speed: Parallel Component	2.36	1.97	knots	14
Perpendicular Component	5.64	3.79	knots	14
Pitch Angle at Touchdown	4.11	0.8	degrees	14
Roll Angle at Touchdown	-2.01	2.3	degrees	14
Yaw Angle at Touchdown	-2.09	5.12	degrees	14
Calculated Glide Slope Angle	0.67	0.49	degrees	14
Distance From Touchdown to Runway Threshold	1060	242	feet	14
Off Center Distance at Touchdown	4.43	5.33	feet	14
Aircraft Reported Landing Weight	79496	4636	pounds	14

AIRCRAFT MODEL McDONNELL DOUGLAS MD-80

Parameter	Mean Value	Standard Deviation	Measurement Units	Number of Landings
Sinking Speed: Port Wheel	2.55	1.7	ft/sec	118
Starboard Wheel	2.58	1.62	ft/sec	118
Average of Main Wheels	2.57	1.57	ft/sec	118
Closure Speed (Measured to Camera)	137.2	10.33	knots	118
Approach Speed	139.4	10.14	knots	118
Wind Speed: Parallel Component	2.2	2.47	knots	118
Perpendicular Component	5.81	3.04	knots	118
Pitch Angle at Touchdown	5.3	1.4	degrees	118
Roll Angle at Touchdown	-1.08	2.36	degrees	118
Yaw Angle at Touchdown	-3.78	5.22	degrees	118
Calculated Glide Slope Angle	0.64	0.38	degrees	118
Distance From Touchdown to Runway Threshold	1147	231	feet	118
Off Center Distance at Touchdown	2.86	4.39	feet	118
Aircraft Reported Landing Weight	114094	10824	pounds	97

LANDING DATA MODEL AIRBUS A-320 AIRCRAFT
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
35	144	143	8.1	8.8	8.4	135400	941	1	2.0	8.1	-3.2	-7.8	2	9
62	141	140	7.8	7.9	8.0	102051	624	2	1.9	7.2	-7.0	0.1	1	8
173	151	149	2.7	2.1	2.4	125607	1011	4	0.6	5.9	-5.9	-5.9	2	9
180	122	118	1.8	2.4	2.1	130900	1112	4	0.6	8.0	1.9	0.8	4	7
209	134	133	1.9	2.3	2.1	132500	1235	6	0.5	8.1	0.3	0.1	1	12
277	131	125	5.2	7.5	6.8	125711	594	9	1.8	7.9	-2.1	2.7	6	8
295	127	124	1.7	3.4	2.6	134900	1022	5	0.7	7.5	1.4	5.4	3	10
423	136	130	1.8	3.7	3.3	125052	1149	8	0.9	5.6	2.3	-0.7	6	8
487	135	127	0.9	2.1	1.5	137500	1221	3	0.4	6.2	1.5	-2.1	8	6
508	140	137	6.9	4.2	5.6	126711	904	2	1.4	5.2	-4.2	-7.0	3	0
524	142	140	0.8	0.6	0.7	120900	1452	-5	0.2	6.2	-1.0	-11.3	2	0
541	124	124	3.5	2.2	2.8	118036	1149	2	0.8	4.6	0.0	-1.0	0	1
605	137	137	1.1	2.8	2.3	126800	1236	3	0.6	8.0	0.6	-1.0	1	3
630	151	148	1.4	1.7	1.7	127828	1386	-3	0.4	5.1	0.2	-9.2	3	-1
661	144	144	1.2	0.4	0.5	136700	1294	-1	0.1	5.8	0.1	-2.2	1	1
687	121	126	0.3	0.4	0.4	121464	1245	-4	0.1	7.0	-1.7	-1.2	-5	2
735	145	146	3.7	3.2	3.5	121007	892	8	0.8	7.1	-1.7	-5.1	-1	8
798	130	126	1.4	2.5	2.1	133520	1208	-5	0.6	6.5	2.9	-4.1	3	7
808	135	132	1.4	2.2	1.8	125743	936	1	0.5	6.7	-4.4	-4.2	3	5
885	123	121	5.4	3.5	4.4		936	3	1.2	5.1	-4.1	-4.2	3	5
916	143	143	5.0	6.6	5.8	125700	1055	-1	1.4	5.5	-2.6	-12.7	0	3
949	146	142	2.2	5.6	3.9	125779	1003	17	0.9	5.9	2.6	1.4	4	5
958	147	145	3.3	3.4	3.3	125300	1042	-6	0.8	6.8	-4.6	-9.9	2	6
963	133	129	0.3	0.2	0.2	125743	1348	8	0.1	7.7	-0.7	-5.1	4	5
1010	152	151	3.4	3.3	3.3		1080	-5	0.7	5.8	-4.9	-11.3	1	4
1072	139	141	0.5	0.4	0.4	129200	1511	-9	0.1	8.8	0.4	-13.5	-3	5

LANDING DATA MODEL BOEING 727-200 AIRCRAFT
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
2	144	136	0.9	0.1	0.5	134583	1286	4	0.1	5.4	-1.2	-5.3	8	6
9	132	130	4.4	4.3	4.3	133555	845	3	1.1	4.9	-3.6	-1.9	3	8
34	136	134	2.6	3.3	3.0	138109	1149	6	0.7	5.4	1.6	2.6	2	9
42	136	134	0.4	0.1	0.2		1400	6	0.0	6.5	-2.5	-5.0	2	5
49	118	115	0.4	1.4	0.9	135500	1213	1	0.3	5.8	0.3	1.5	3	8
65	128	127	3.7	3.6	3.6		693	2	1.0	4.2	-6.8	1.6	1	6
74	143	140	5.9	3.5	4.7	142173	1017	-6	1.1	7.4	-4.6	-9.4	3	8
94	127	123	2.5	2.1	2.3	140368	1968	-18	0.6	1.8	0.4	3.0	4	7
100	136	132	0.9	0.6	0.7		1214	6	0.2	4.5	-0.1	-3.9	4	5
113	140	140	1.3	0.6	1.0	129204	1246	8	0.2	8.2	1.5	-6.9	0	7
117	146	147	1.2	2.3	1.7		1351	5	0.4	5.9	-3.6	-3.2	-1	6
126	151	148	0.0	2.4	1.3	142130	1300	5	0.3	5.1	2.7	-7.4	3	8
138	153	153	1.2	1.4	1.3		1258	1	0.3	6.1	-0.2	-6.4	0	7
147	155	155	0.2	0.2	0.2	144122	1429	2	0.0	3.9	0.7	-8.5	0	5
158	148	147	4.1	2.5	3.3		951	7	0.8	3.8	1.4	2.0	2	6
162	133	131	0.2	2.8	1.5		1437	0	0.4	4.5	1.5	-10.4	3	5
164	141	138	1.5	1.4	1.4	145113	2377	-7	0.4	3.2	-2.1	-3.8	3	6
176	130	128	1.6	1.9	1.2		1117	0	0.3	4.8	2.5	-0.5	2	6
181	156	152	0.7	4.0	2.3	136000	1355	1	0.5	4.8	0.8	-4.9	5	7
188	139	133	2.5	2.2	2.4	145761	2251	-1	0.6	3.9	2.0	2.0	6	8
190	146	143	2.9	0.6	1.7	151601	1222	9	0.4	8.9	0.0	-1.1	3	9
192	126	125	8.4	6.8	7.6	132000	1039	18	2.1	8.2	-1.8	4.9	2	10
218	149	147	0.4	0.4	0.4		1351	3	0.1	4.9	0.2	-3.7	1	7
225	149	146	5.3	5.4	5.3	142000	967	4	1.2	7.2	-4.0	-6.7	3	8
234	143	137	1.0	1.1	1.1	150872	1215	3	0.3	6.3	0.9	-2.2	7	11
235	140	136	0.6	0.3	0.4		1114	5	0.1	5.4	0.3	0.3	4	10
253	143	142	2.3	1.8	2.4	147165	1184	3	0.6	5.1	-0.7	0.6	1	8
270	136	133	1.2	1.8	1.5		1206	3	0.4	5.8	-0.4	1.2	3	6
274	136	130	4.3	5.8	5.1	151610	825	-1	1.3	3.1	-2.9	0.5	6	8
281	137	132	6.2	6.4	6.4	145835	885	7	1.6	3.2	-4.4	-3.9	5	8
292	139	134	2.6	1.8	2.2	145835	954	2	0.6	4.9	-3.8	-6.1	5	10
325	153	146	0.0	0.4	0.2		1034	3	0.0	3.9	0.5	-10.2	6	9
343	140	136	0.5	1.9	1.2	132363	1474	-6	0.3	7.2	0.8	-13.3	4	8
346	129	127	1.3	0.0	0.5		1091	15	0.1	5.0	1.1	0.8	3	10
359	130	124	4.0	3.8	2.8	147400	1115	6	0.8	5.2	2.0	1.4	6	13
361	139	134	2.2	1.4	1.9		1190	2	0.5	4.5	1.9	-1.9	6	10

LANDING DATA MODEL BOEING 727-200 AIRCRAFT (Continued)
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
367	144	138	6.7	4.9	5.6	149209	704	4	1.4	4.9	-7.3	1.2	6	8
381	123	119	1.5	1.8	1.7	123282	1168	0	0.5	5.1	0.0	-0.5	3	9
384	143	140	2.8	4.4	3.6		1058	-3	0.9	3.5	-3.2	-14.8	3	8
402	130	122	1.4	1.5	1.6		1222	-7	0.4	4.3	-2.0	2.6	8	9
412	137	132	5.8	5.6	5.4	140385	917	5	1.4	6.6	1.3	2.1	5	8
414	172	167	0.3	0.3	0.3	145860	1222	9	0.0	4.5	1.3	-5.6	6	7
417	155	148	1.5	2.6	2.0	149509	1359	5	0.5	5.0	3.6	-7.1	7	7
422	144	139	0.3	0.8	0.6		1494	-6	0.1	7.2	1.0	-13.0	5	8
434	134	129	0.1	1.0	0.5		1186	7	0.1	5.1	0.9	-2.2	5	4
448	128	124	0.3	1.0	0.6	142080	1030	13	0.2	6.5	-1.1	-1.4	4	5
453	135	130	2.1	1.5	1.7	145104	1139	3	0.4	6.0	1.7	-1.1	5	8
464	129	123	1.3	1.1	1.5	148648	1133	7	0.4	6.1	0.9	0.1	5	6
473	136	133	3.8	6.8	4.7	145702	554	3	1.2	8.2	-5.3	7.1	3	8
492	135	131	0.6	1.8	1.2	146467	1398	2	0.3	7.0	2.8	-8.4	4	4
493	140	136	3.2	5.1	4.0		662	9	1.0	4.3	5.8	5.0	4	5
500	149	144	1.0	0.7	0.9	129857	1279	-1	0.2	5.5	0.7	-2.0	5	0
523	136	134	3.3	2.0	2.7		894	1	0.7	2.1	-6.8	-5.1	2	0
528	147	144	1.5	1.8	1.6	138000	1313	2	0.4	6.2	0.2	-8.0	4	0
570	149	149	0.6	2.0	1.3	146677	1455	-7	0.3	7.8	-2.0	-11.7	0	-3
579	141	140	4.2	2.0	3.1	141271	1216	4	0.7	5.9	0.1	-4.4	1	-2
580	131	130	3.6	0.5	2.3	138750	1156	1	0.6	8.1	-3.7	-1.3	1	-4
583	124	124	1.1	0.1	0.5		1108	2	0.1	4.5	-2.5	1.7	0	-3
596	139	141	0.6	1.3	1.0	133879	1448	5	0.2	7.9	0.1	-13.6	-2	1
609	137	137	0.5	2.2	1.4	139761	2644	5	0.3	5.4	2.4	-0.7	1	2
618	143	142	3.6	4.4	3.5	107521	965	17	0.8	6.0	1.3	-2.3	1	2
629	140	139	2.1	1.5	2.1		1071	2	0.5	5.7	-1.3	0.4	2	3
634	95	93	2.7	4.5	4.1	124500	1040	7	1.5	5.5	4.3	2.1	2	-1
644	130	132	8.8	5.6	7.2		768	7	1.8	5.3	-5.3	0.2	-2	1
645	147	147	2.1	3.7	3.3	140000	1229	8	0.8	5.4	1.3	-5.8	0	3
653	148	151	4.8	5.0	4.9	145721	1005	6	1.1	5.7	-4.9	-8.6	-3	1
666	134	136	5.9	5.7	5.0	143399	1094	11	1.2	7.2	-3.0	1.5	-2	2
670	111	116	1.4	2.3	1.8	143220	914	19	0.5	7.2	1.2	3.9	-4	4
710	133	137	8.7	7.2	7.0	136344	523	1	1.7	8.0	-11.8	4.2	-5	-2
715	149	152	0.7	1.8	1.2		1337	3	0.3	5.2	0.2	-7.2	-3	0
728	154	155	1.5	2.0	2.1	131083	1238	4	0.5	4.2	1.5	-3.4	-1	9

LANDING DATA MODEL BOEING 727-200 AIRCRAFT (Continued)
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
740	150	150	0.3	0.3	0.7	146716	1296	2	0.2	6.3	2.3	-6.1	-1	5
748	143	144	1.9	3.6	3.1	146763	1321	0	0.7	7.1	3.7	-6.3	-1	8
755	150	152	3.9	3.3	3.6		1005	5	0.8	1.9	-4.2	-8.6	-1	7
766	131	133	3.1	2.2	2.5	145954	886	0	0.6	6.3	-2.7	-1.0	-2	10
788	147	145	4.2	4.1	4.0		932	3	0.9	3.5	-3.7	-4.7	2	6
801	131	130	0.1	0.6	0.4	146736	1399	6	0.1	5.5	1.2	-11.8	1	7
816	126	123	1.2	1.8	1.4	137000	1107	10	0.4	4.3	3.7	3.0	2	5
818	141	138	2.8	1.7	1.9	144909	1354	5	0.5	4.9	3.0	-8.3	3	8
826	135	131	3.2	3.3	3.1	145522	1241	9	0.8	5.9	1.3	-3.5	4	6
834	134	133	0.9	1.4	1.2		1204	2	0.3	4.5	1.4	-1.6	1	4
850	150	148	1.5	2.3	2.1		1381	11	0.5	5.4	0.5	-7.9	2	5
863	155	155	0.7	0.5	0.6	136364	1534	-16	0.1	6.4	-1.0	-12.4	0	5
871	126	127	3.7	4.4	4.1	134541	1069	7	1.1	5.6	1.5	-0.8	-1	4
874	150	148	1.7	1.9	1.8	148400	1369	-1	0.4	5.3	-2.6	-7.5	3	5
878	137	134	0.9	3.2	2.5		1130	8	0.6	3.1	3.3	0.6	3	5
884	135	133	1.2	2.8	2.0	182567	1320	5	0.5	5.8	0.0	-4.6	3	4
899	148	145	0.2	0.2	0.2		1318	7	0.1	2.9	-0.7	-6.1	3	5
904	146	146	0.1	1.1	0.9	135181	1307	9	0.2	4.7	2.4	-4.9	0	7
910	144	143	0.7	0.3	0.5	136447	1385	0	0.1	5.5	3.4	-10.3	1	3
923	149	147	0.4	1.0	0.7		1302	7	0.2	3.7	2.9	-5.8	2	6
926	156	150	0.1	1.2	0.7	145125	1319	3	0.2	5.9	2.0	-5.6	6	8
952	145	141	1.4	0.3	1.0	136397	1228	7	0.2	4.4	-1.5	-4.1	4	5
967	154	150	0.3	0.8	0.6	135800	1366	2	0.1	4.0	0.6	-6.5	4	8
976	141	137	3.7	7.7	6.7	136000	902	3	1.7	5.5	-3.1	-6.9	4	6
982	150	146	3.8	4.4	4.1	133700	1024	1	1.0	4.2	-4.0	-12.3	4	5
985	149	146	0.1	0.1	0.1		1373	1	0.0	3.6	0.6	-4.7	3	4
1005	136	135	1.6	1.4	1.5		1313	3	0.4	5.9	-0.4	-4.6	1	4
1023	106	105	3.6	4.9	4.3	135000	965	2	1.4	7.2	0.1	4.4	1	4
1026	133	132	0.8	2.3	1.9	133962	1182	3	0.5	4.3	2.9	-2.9	2	4
1032	143	143	1.1	1.2	1.5		1212	-3	0.4	5.0	1.4	-0.5	1	3
1036	131	129	0.6	1.8	1.2	146657	1184	-5	0.3	5.8	1.2	-1.5	2	3
1041	134	134	3.7	3.4	3.5	145793	1093	9	0.9	6.0	-0.1	-1.7	1	3
1053	128	127	0.5	1.2	0.6	128810	1058	7	0.2	3.3	1.5	0.5	1	2
1055	154	156	5.8	6.9	6.3		816	-1	1.4	3.5	-4.9	-0.5	-2	3
1068	139	142	6.0	5.6	5.8	146967	824	-3	1.4	3.9	-5.1	-2.3	-2	4

LANDING DATA MODEL BOEING 737-100/200 AIRCRAFT
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Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
1	129	125	1.5	1.6	1.5	77990	1272	3	0.4	2.9	-1.2	-2.4	4	6
13	125	118	0.1	1.2	0.6	103610	1221	-2	0.2	6.9	2.4	-0.9	7	6
28	146	141	1.4	1.2	1.3	102115	1477	-5	0.3	6.2	2.3	-11.4	5	9
29	143	139	1.5	3.4	2.7	96282	1008	6	0.7	9.1	1.7	4.7	5	8
30	123	118	1.0	0.4	0.8		1298	-1	0.2	5.6	-0.9	-3.6	6	7
32	148	146	1.7	3.3	2.8	110790	1262	3	0.6	7.4	3.1	-4.5	2	7
44	152	148	0.6	0.2	0.4	109183	1202	3	0.0	4.3	-2.8	0.4	4	6
45	146	143	0.6	0.3	0.4		1384	1	0.1	6.4	-0.2	-6.8	2	7
50	130	131	0.3	0.3	0.3	88410	1248	5	0.0	2.6	3.2	-2.4	-1	10
52	161	157	3.5	2.8	3.1	110412	855	5	0.7	3.2	-3.2	-2.1	4	7
53	138	138	4.8	4.0	4.2	94358	808	7	1.0	3.6	-1.3	-5.0	1	8
56	137	132	0.1	0.5	0.3	95835	1226	11	-0.1	4.4	0.8	-3.1	4	9
84	150	146	0.7	1.4	1.1	97981	1302	4	0.3	7.2	2.2	-6.3	5	8
88	143	139	1.2	2.3	1.8		1310	15	0.4	4.8	0.6	-4.8	5	8
91	132	130	0.6	0.1	0.3		1433	4	0.1	5.7	1.4	-8.3	2	9
125	132	131	3.0	1.8	2.4	86601	1110	5	0.6	5.6	1.2	-1.0	1	5
128	135	133	2.1	3.4	2.8	114500	1213	4	0.7	5.7	1.5	-0.3	2	8
143	156	153	1.1	0.0	0.6	114085	1286	0	0.1	7.3	0.0	-4.9	3	7
151	138	135	2.2	4.0	3.1	89401	540	3	0.8	6.2	-4.5	8.6	3	8
155	130	126	2.3	1.5	1.9	106043	1040	9	0.5	6.1	-2.0	4.8	4	5
160	146	145	0.1	0.2	0.1		1265	13	0.0	6.8	-1.0	-2.3	1	8
163	121	114	4.8	3.7	4.3	98993	832	2	1.3	7.1	-1.9	-0.9	7	10
169	136	134	2.2	1.1	1.6		1205	4	0.4	6.9	0.3	-3.0	2	9
177	155	152	3.4	3.0	3.2	112238	986	1	0.7	5.5	-5.9	-7.3	4	6
183	154	151	0.3	0.7	0.5	98910	1358	3	0.1	5.2	1.2	-7.4	3	6
196	135	132	4.1	2.8	3.4	105084	775	11	0.9	6.5	-4.0	-0.1	3	9
203	137	137	3.9	4.7	4.8	112544	853	2	1.2	5.9	-3.1	-4.4	0	13
204	136	136	1.3	2.5	1.9	100861	1061	10	0.5	5.4	2.5	5.9	0	12
213	133	127	1.5	1.4	2.0		1219	0	0.5	5.8	2.0	-2.2	5	7
216	151	149	1.1	1.2	1.2	98105	1411	6	0.3	5.5	1.9	-7.2	2	11
221	150	145	0.5	1.5	1.0	103520	1179	8	0.2	4.4	1.3	1.3	5	11
231	133	130	0.1	0.3	0.2		1340	7	0.0	2.5	3.7	-4.1	2	9
232	147	144	4.5	4.3	4.4	98537	687	3	1.0	5.5	-4.5	2.6	3	12
233	143	141	1.1	1.9	1.5	113703	1178	6	0.4	5.6	-1.0	0.7	2	8
236	142	140	6.2	7.7	7.0	105155	697	3	1.7	8.5	-3.5	-0.5	2	12
237	143	142	4.6	3.5	5.2	91340	881	4	1.2	6.3	-1.7	-4.8	1	10

LANDING DATA MODEL BOEING 737-100/200 AIRCRAFT (Continued)
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Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
243	139	136	1.0	3.7	2.7	100734	1185	8	0.7	2.7	6.0	-3.9	3	15
259	135	136	0.5	0.5	0.5	104753	922	13	0.1	7.1	3.1	4.8	-1	9
288	146	140	3.6	4.6	4.1	97818	704	5	1.0	9.8	-3.0	0.6	6	10
290	133	130	5.0	4.0	4.5	105100	850	1	1.2	7.1	-5.1	-2.5	3	6
291	136	132	3.2	3.5	3.4	94811	844	6	0.9	3.6	-3.9	-0.9	3	9
293	133	129	3.8	4.1	4.0	96230	887	7	1.0	5.0	-4.5	-3.4	4	5
294	140	133	1.7	3.4	2.5	91231	984	8	0.6	1.5	1.4	5.8	7	8
302	143	140	6.1	4.2	5.4	110077	887	2	1.3	4.2	-2.0	-4.0	3	12
304	123	122	1.6	1.6	1.6	114565	1201	7	0.4	5.1	-0.6	-0.6	1	11
306	136	132	4.6	3.2	4.0	101355	880	4	1.0	2.9	-6.1	-2.6	4	8
309	136	132	0.2	0.9	0.5	123700	1141	2	0.1	5.9	0.0	3.0	3	9
311	131	127	4.8	8.2	6.5	89895	770	0	1.7	4.6	-1.7	-1.8	4	11
318	134	131	1.7	2.4	1.9	96062	1126	8	0.5	5.1	1.5	0.0	3	9
323	135	131	0.0	0.6	0.3	103758	1199	9	0.1	4.9	2.7	-0.3	4	8
348	136	135	0.9	0.2	0.6	97120	1229	4	0.1	5.1	0.2	-1.0	2	9
353	142	138	2.0	3.0	2.5	94402	1029	12	0.6	7.3	2.9	-0.1	4	11
356	140	138	2.4	2.2	2.3	97360	961	0	0.6	4.3	-5.8	-2.4	2	9
368	127	125	1.8	2.5	2.3	121100	1190	9	0.6	6.8	1.9	4.5	2	11
396	140	136	1.1	2.5	2.2	83116	1268	2	0.6	3.7	5.2	-3.4	4	6
399	145	140	1.1	2.2	1.7	111188	1018	9	0.4	5.6	0.3	1.6	4	5
407	143	135	0.6	1.7	1.0	109523	1108	8	0.2	2.8	0.9	-0.9	8	6
425	110	105	1.8	2.4	2.2	93358	1031	9	0.7	3.6	1.6	2.4	5	6
429	141	135	3.2	3.1	3.2	106270	920	4	0.8	8.0	0.0	5.1	7	6
447	133	127	0.9	3.6	2.2	108585	1074	5	0.6	6.3	1.4	5.0	6	7
450	139	134	0.2	0.3	0.2	103125	1347	9	-0.1	5.2	-0.1	-4.3	5	3
451	143	137	2.8	7.1	4.3	112412	920	0	1.1	8.2	3.3	6.4	6	6
475	125	122	1.4	0.1	0.8	99737	1253	0	0.2	5.8	-1.4	0.7	3	4
480	151	147	1.9	1.3	1.5	108454	1035	-1	0.3	6.3	0.1	2.5	4	6
485	158	153	1.4	0.8	1.1	106600	1375	1	0.1	2.9	-3.0	-7.6	6	4
488	122	116	2.4	1.1	2.5	93820	1099	1	0.7	3.5	-2.5	4.9	6	6
489	135	129	1.8	1.5	1.7	102816	1105	3	0.4	9.9	-1.0	1.7	6	5
517	139	138	2.5	0.7	1.6	113133	987	-4	0.4	3.4	-6.8	-6.7	1	0
519	160	156	1.2	0.2	0.7	114180	1331	3	0.1	4.7	-0.8	-9.9	4	0
520	134	132	1.8	2.1	2.6	110270	1196	3	0.7	5.2	1.6	-1.8	2	0
521	145	142	1.0	1.4	1.2		1296	3	0.3	1.7	0.0	-7.6	3	1
526	145	143	2.1	2.4	2.3	98742	1122	7	0.5	5.2	0.3	-4.0	2	0

LANDING DATA MODEL BOEING 737-100/200 AIRCRAFT (Continued)
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Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
527	138	133	1.8	0.9	1.8	95954	1077	-5	0.5	4.7	-2.5	2.0	5	1
545	124	125	6.3	5.1	5.7	108770	797	3	1.5	8.7	-5.1	-1.0	-1	1
571	118	121	0.9	0.2	0.7	94213	1233	-1	0.2	7.4	-1.4	-0.3	-3	-1
576	144	147	1.4	1.1	1.2	102140	1470	-3	0.3	5.3	0.1	-13.0	-2	-2
599	133	133	2.4	1.0	1.7	101597	1302	1	0.4	3.7	-4.1	-2.1	0	3
603	145	147	2.5	4.6	3.5	102225	1020	-7	0.8	3.2	-3.7	-6.2	-2	1
625	138	137	0.3	1.6	0.7		1107	8	0.2	4.5	-0.5	0.8	1	-2
641	151	151	4.5	3.4	4.0		979	2	0.9	4.8	-8.3	-6.9	1	1
646	127	129	2.6	2.4	2.5		1122	5	0.7	4.5	0.1	-2.6	-2	1
647	143	143	2.6	1.7	2.4		1273	2	0.6	6.4	-2.5	-2.7	0	1
660	129	128	3.2	3.1	3.1		1033	9	0.8	9.6	-2.4	1.0	2	3
667	132	134	0.1	0.5	0.3		1169	8	0.1	4.9	-0.4	0.2	-1	3
673	152	152	0.9	1.4	1.1	107618	1351	8	0.2	6.0	1.4	-3.9	-1	2
681	155	158	0.5	0.4	0.4		1309	8	0.0	6.1	-2.5	-3.5	-3	3
695	129	134	2.6	1.6	2.4		1124	6	0.6	3.0	-1.9	-0.3	-5	-1
705	147	151	3.0	2.0	2.7	104287	1250	3	0.6	3.4	-1.6	-2.9	-4	1
708	131	134	1.9	2.8	2.1		983	9	0.5	6.2	-2.3	0.5	-4	-3
724	137	138	5.0	4.7	4.5	93442	1006	-3	1.1	4.0	-5.7	-8.5	-1	7
725	139	139	0.0	1.2	1.7		1146	4	0.4	2.5	2.7	2.1	0	11
742	124	124	0.9	0.7	0.8	96363	1270	0	0.2	5.0	4.2	-4.6	0	7
746	154	154	5.2	5.3	5.3	95747	993	-1	1.2	4.4	-4.4	-5.2	0	9
747	154	154	3.0	1.2	2.0	111420	910	1	0.4	4.9	-1.7	-6.3	0	9
759	146	146	0.2	0.5	0.4		1328	4	0.1	5.8	2.1	-3.7	0	11
799	147	146	0.4	0.9	0.6	103627	1272	1	0.2	3.1	1.5	-5.2	1	5
802	139	139	0.5	0.2	0.4	94832	1427	-1	0.0	4.2	0.4	-6.8	1	5
803	146	144	0.3	3.2	1.5	111400	1197	5	0.4	4.6	2.9	-6.1	2	6
815	142	140	1.9	5.3	3.7	113353	931	10	0.9	9.7	4.3	2.1	2	3
820	154	150	0.3	1.1	1.1	97260	1245	8	0.3	3.4	2.7	-3.5	4	6
821	138	138	0.8	2.2	1.4		1134	3	0.4	5.7	2.2	1.2	0	7
827	140	136	2.2	2.8	2.5	84840	958	0	0.6	7.9	-5.1	-8.4	4	6
859	168	166	1.3	3.4	3.3	94109	990	4	0.7	4.3	-0.1	4.8	3	5
903	154	153	2.8	3.3	3.1	99210	1057	0	0.7	7.2	-3.9	-12.9	1	6
905	146	145	5.2	5.0	5.3	102957	916	2	1.2	7.2	-1.6	-8.3	1	4
909	121	121	0.9	2.5	1.3	86065	1084	2	0.4	7.0	-2.3	-3.7	0	6
913	145	144	3.7	2.6	3.2	109935	875	1	0.8	3.0	-5.1	-2.4	1	5
924	131	130	4.0	4.5	4.2		785	3	1.1	4.2	-2.4	-1.2	1	5

LANDING DATA MODEL BOEING 737-100/200 AIRCRAFT (Continued)
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Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
934	138	138	2.7	3.7	3.4	92405	698	6	0.8	5.5	-3.8	1.0	0	7
942	151	147	2.3	3.4	3.2	94280	967	-1	0.7	6.5	-4.2	-9.3	5	8
968	146	142	1.6	0.9	1.2	115224	1245	6	0.3	6.1	-0.2	-5.9	4	7
970	142	138	2.5	1.7	2.5	103700	1181	6	0.6	6.6	-0.8	-0.5	4	5
974	118	114	2.8	3.1	3.0	90860	1164	1	0.9	9.3	0.0	-1.7	4	6
989	147	143	2.9	1.1	2.0	106175	1271	1	0.5	6.1	1.0	-0.6	4	6
1007	140	141	4.6	4.5	4.6	102699	801	4	1.1	3.5	-4.7	-0.4	-1	5
1016	121	121	0.4	0.3	0.7	95336	1372	0	0.2	3.5	0.3	-4.3	0	4
1028	149	147	2.4	3.0	2.7	89668	970	1	0.6	4.4	-3.3	-6.1	2	3
1063	145	146	0.6	2.7	1.6	101884	1058	1	0.4	5.5	-5.5	-10.7	-2	4
1066	141	141	0.4	0.5	0.4	108961	1280	1	0.1	3.9	0.0	-2.2	-1	3
1069	140	141	2.4	1.5	2.0		1465	0	0.5	2.4	-1.1	-11.6	-1	6

LANDING DATA MODEL BOEING 737-300/400/500 AIRCRAFT
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
405	137	129	2.5	1.9	2.2		1896	-12	0.6	4.9	0.8	1.9	8	6
539	149	149	1.4	0.9	1.2	98726	1435	8	0.3	3.6	1.4	-9.0	1	0
696	130	132	2.4	2.1	2.2		1998	-10	0.6	4.6	-0.8	-1.2	-2	-2
763	153	150	1.8	4.1	3	114988	1047	3	0.7	5.8	-3.4	-11.5	3	8
925	140	136	3	3.7	3.7	111150	859	8	0.9	8.9	-3.6	-7.1	5	8
992	162	160	0.2	1.2	0.9	112908	1359	0	0.2	5.8	0.6	-6.9	3	6
1020	151	151	3.3	3.3	3.2	100009	954	3	0.7	6.4	-3.8	-3.8	-1	3
1057	122	122	6.6	5.9	6.3		632	2	1.7	7.3	-4.9	2.1	0	5

LANDING DATA MODEL BOEING 757 AIRCRAFT
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
18	127	123	2.2	3.4	2.8	174331	1063	1	0.8	6.9	1.5	2.5	4	5
38	138	134	1.4	2.0	1.7	180065	1377	11	0.4	7.0	0.6	-4.3	3	9
61	127	127	3.2	3.1	3.2	177284	863	5	0.8	6.3	0.2	5.5	1	10
70	127	123	3.4	1.1	2.3	164000	999	9	0.6	4.2	0.5	3.8	3	5
76	137	135	6.6	6.2	6.4	178500	1062	-4	1.6	7.1	-4.4	-13.4	2	4
96	122	121	1.4	0.4	0.3	156000	1276	11	0.1	7.8	1.4	-3.3	2	6
167	133	128	0.8	1.5	1.4	175196	1175	5	0.4	4.6	1.9	0.8	4	5
174	127	126	1.9	0.7	1.3	169668	1232	5	0.3	6.7	-0.9	-2.8	1	7
194	126	122	1.3	2.2	2.2	174258	945	2	0.6	7.2	-4.6	-6.1	4	11
206	135	133	7.7	8.6	8.1	168000	587	7	2.1	6.7	-4.7	2.1	2	10
207	129	129	0.9	2.7	2.0	181340	1115	16	0.5	7.4	3.4	-1.1	1	11
219	123	120	3.7	3.0	3.3	176200	1996	-21	0.9	6.2	1.4	-0.9	3	8
227	127	123	0.6	1.8	1.5	180000	1132	8	0.4	5.9	1.8	-2.1	4	11
246	138	137	6.2	7.6	6.9	182959	511	10	1.7	6.1	-5.5	4.2	1	8
247	135	134	3.6	3.2	3.4	175652	961	3	0.9	5.9	-4.5	-6.9	1	7
275	124	119	4.6	4.2	4.3	164624	931	11	1.2	7.2	-5.0	-7.8	5	9
298	133	128	3.1	2.2	2.6	175462	928	2	0.7	6.7	-4.2	-7.9	5	8
312	131	128	4.8	4.1	4.5	167518	938	6	1.2	7.1	-3.7	-5.4	4	8
320	120	116	1.3	2.9	1.9	171490	1402	1	0.6	7.1	-1.5	-8.5	5	8
330	140	135	2.7	4.4	3.6	172740	965	4	0.9	5.8	-2.9	-7.9	5	10
341	144	141	3.0	4.1	3.5	185500	1056	2	0.8	7.4	-4.1	-12.2	3	8
391	126	123	0.8	1.3	1.1	164204	1268	11	0.3	7.3	0.8	-5.3	4	10
403	145	139	0.1	1.1	0.6	187750	1328	11	0.1	4.7	2.1	-8.6	6	6
432	126	121	1.6	3.4	2.4	183893	1034	6	0.7	8.2	1.4	3.7	5	6
459	136	131	2.2	2.6	2.4	176865	2018	-16	0.6	2.7	-0.4	-2.0	5	5
470	131	127	0.6	3.7	2.2	176893	1039	6	0.5	7.6	2.0	3.4	3	7
474	123	119	4.1	4.6	4.3	160100	887	6	1.2	7.7	-1.0	7.4	4	5
486	134	129	0.2	0.7	0.5	179000	1417	-2	-0.1	5.6	0.7	-8.5	5	3
490	123	119	1.5	2.7	2.5		1206	-5	0.7	5.7	1.4	-3.1	4	3
507	115	112	3.6	5.2	4.4	157461	692	2	1.3	6.5	-4.8	-0.3	3	0
513	121	119	0.7	2.0	1.5	169653	1066	7	0.4	5.0	0.3	0.2	2	0
537	121	120	2.0	1.6	1.8	175793	1075	6	0.5	7.3	-0.3	2.1	1	2
550	130	132	1.4	1.1	1.2	179540	1316	3	0.3	6.9	-0.5	-5.4	-2	1
558	142	143	2.5	1.6	2.1	188600	1344	0	0.5	5.7	0.4	-8.5	-1	1
572	134	133	1.4	1.6	1.5	178032	1298	5	0.4	4.3	0.9	-6.3	1	0

LANDING DATA MODEL BOEING 757 AIRCRAFT (Continued)
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
577	140	141	0.1	0.2	0.2	182490	1401	7	0.0	6.1	0.7	-13.2	-1	0
627	139	137	3.4	2.0	2.7		2191	-5	0.7	4.0	0.0	2.6	2	0
650	134	132	7.8	7.6	6.9	185923	754	-12	1.8	7.7	-7.1	-0.6	2	2
654	130	132	4.0	4.5	4.1	182726	1155	13	1.1	4.9	1.8	-3.4	-2	2
658	124	125	2.1	2.1	1.8	178969	1197	1	0.5	4.8	-0.1	-1.6	-1	2
672	132	136	2.1	2.5	2.3	172291	1236	4	0.6	5.0	-0.2	-3.7	-4	1
679	152	152	1.1	1.3	1.2		1248	4	0.3	5.4	1.1	-4.2	0	2
727	139	140	0.6	0.3	0.6	174727	1334	2	0.2	6.5	0.4	-6.6	-1	7
736	140	139	8.0	5.0	6.3	179626	806	4	1.5	5.2	-2.4	0.3	1	7
756	131	133	4.5	7.7	6.1	179069	774	0	1.6	6.7	-1.5	0.0	-1	8
787	145	145	2.7	4.2	3.5	169445	893	5	0.8	5.4	-4.2	-9.2	0	9
831	127	125	1.5	1.9	1.7	176317	1131	15	0.5	6.4	-1.0	0.6	2	5
842	124	122	1.1	0.9	1.0		1278	2	0.3	7.0	0.7	-3.6	3	5
853	124	123	2.2	3.2	2.6	180100	1138	-2	0.7	6.4	-1.0	2.2	1	5
866	130	129	2.3	5.0	4.2	176650	1044	6	1.1	5.2	1.3	2.1	1	4
877	125	122	0.4	0.3	0.4		1213	5	0.1	5.3	-0.2	0.7	3	6
930	135	133	0.8	3.2	2.6	187000	1229	14	0.7	5.6	1.2	-7.9	2	7
956	122	120	1.8	0.6	1.1	163817	1263	-4	0.3	6.7	-0.8	-3.3	3	3
957	131	126	2.6	2.8	2.7		902	0	0.7	6.9	-5.1	-7.6	5	3
969	134	131	1.2	1.1	1.1	161888	1346	8	0.3	5.5	0.8	-5.7	4	6
990	142	140	1.2	1.6	1.4	183143	1354	5	0.3	6.5	2.1	-8.6	2	7
991	143	141	0.2	0.2	0.3	175800	1256	10	0.1	5.5	1.0	-5.6	2	7
999	132	127	0.2	0.5	0.4		1085	7	0.1	8.5	1.8	0.0	5	6
1034	137	137	1.0	2.5	1.7	180108	1100	-2	0.4	6.7	-1.1	-0.2	0	3
1056	130	128	2.0	2.0	2.0	172560	798	3	0.5	5.6	-5.8	-2.5	2	3

LANDING DATA MODEL CANADAIR REGIONAL JET
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
172	149	149	7.9	8.1	8.0		967	0	1.8	5.0	-3.3	-12.4	0	6
347	147	142	3.7	3.3	3.5		706	5	0.8	6.0	-4.6	-0.7	5	9
437	105	102	2.8	4.0	3.4		731	-4	1.1	4.4	-0.3	0.5	4	5
879	135	132	0.6	1.4	1.0		1440	1	0.3	4.6	0.2	-7.7	3	5
888	112	110	2.3	1.5	1.9		1066	5	0.6	-0.3	2.3	-0.7	2	6
1030	137	135	2.1	2.9	2.5		1094	6	0.6	0.2	0.8	5.8	1	5
1067	123	125	3.2	3.9	5.0		903	2	1.4	2.6	-3.3	-7.8	-2	6

LANDING DATA MODEL DOUGLAS DC-9 AIRCRAFT
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
51	134	132	3.3	2.8	3.0	84910	1006	20	0.8	5.0	-2.1	2.5	2	8
66	124	122	5.7	5.3	5.5	74000	719	2	1.5	5.0	-6.1	0.7	2	6
69	131	127	1.7	0.4	1.5	92570	952	4	0.4	3.6	-1.2	5.0	4	5
80	148	145	1.1	1.2	1.1	90000	1328	7	0.3	5.9	-0.4	-4.3	3	5
83	143	139	2.4	2.5	2.4	94380	1090	7	0.6	6.0	0.3	-0.2	3	9
95	123	119	3.0	2.0	2.5	81924	1100	8	0.7	6.9	1.6	-1.6	4	7
102	132	129	0.5	0.0	0.3	81281	1324	4	-0.1	3.4	2.1	-7.0	3	8
115	122	123	2.6	1.9	2.0	97100	1115	11	0.5	3.0	3.7	2.7	-1	10
142	117	114	2.3	2.2	2.2	75885	1047	8	0.7	5.1	-0.2	1.4	3	5
149	149	147	5.9	4.1	5.0	90958	878	4	1.1	5.5	-2.2	8.0	2	6
197	143	140	6.8	4.7	5.4	81390	771	7	1.3	3.9	-2.0	3.6	3	9
202	135	133	1.1	3.0	1.8	112544	1097	10	0.5	5.0	2.8	2.3	2	8
212	120	116	1.2	1.8	1.5	101300	1161	5	0.5	4.4	0.9	0.5	5	7
215	137	137	0.1	0.3	0.2	87471	1409	2	0.0	4.7	-0.5	-6.5	0	7
226	122	120	2.0	0.4	1.2	86100	1137	12	0.3	6.9	-0.7	-0.8	2	12
240	129	127	0.7	0.9	0.8	74300	1249	0	0.2	1.6	0.0	1.2	2	11
245	139	136	0.9	0.5	0.7	81281	1242	4	0.2	4.5	0.8	-5.9	3	7
254	132	132	4.4	2.0	2.9		982	8	0.8	4.4	-3.6	-0.1	0	7

LANDING DATA MODEL DOUGLAS DC-9 AIRCRAFT (Continued)
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
282	144	140	4.7	5.5	5.5	88588	653	3	1.3	6.5	-1.7	0.2	3	9
283	141	134	3.7	4.1	3.9	78525	954	2	1.0	3.9	-4.7	-8.5	7	11
296	124	120	1.1	0.9	1.1	81933	1169	6	0.3	3.4	-1.5	2.5	4	6
314	146	144	1.6	2.2	1.9	94097	1248	4	0.4	4.6	2.0	-3.6	2	14
327	131	126	4.6	4.3	4.4	87895	839	3	1.2	4.1	-3.2	-2.6	5	11
329	134	130	1.5	1.6	1.6	71000	1317	0	0.4	3.2	-1.0	-3.8	4	7
344	152	147	4.2	4.7	4.4		883	8	1.0	5.1	-2.0	-2.2	5	13
345	146	143	1.0	0.7	0.9	90000	1429	4	0.2	5.6	-1.3	-11.5	3	12
370	150	146	4.0	3.5	3.8	84720	1017	4	0.9	4.0	-2.8	-10.7	4	9
373	123	120	0.3	1.7	1.5	91912	1072	4	0.4	7.4	3.5	0.0	3	8
378	133	128	0.9	1.0	0.9	81238	1394	3	0.2	5.8	-0.8	-7.7	5	9
408	126	121	2.4	2.8	2.6	77498	1156	7	0.7	4.4	0.3	0.7	5	7
427	138	134	2.9	2.3	2.7	80340	924	4	0.7	5.1	-4.2	4.6	4	7
440	124	123	0.2	1.2	0.7	136800	1193	-8	0.2	5.2	-0.3	-1.8	1	5
443	126	119	0.3	0.4	0.4		1156	3	0.1	4.9	1.6	-2.1	7	7
446	136	130	3.5	2.3	2.9	132384	1225	2	0.8	5.8	-0.6	-0.7	6	8
449	120	116	1.7	3.0	2.4	115000	1090	3	0.7	4.2	0.1	0.0	4	8
471	136	134	0.3	1.0	0.8	82330	1174	-1	0.2	3.7	-1.6	-0.4	2	9
479	132	127	1.4	1.3	1.4	84875	1119	2	0.4	4.4	-0.1	1.9	5	6
491	130	125	2.0	0.3	1.2	77498	1056	12	0.4	4.9	-2.0	0.3	6	6
552	144	143	0.8	3.2	2.0	94200	1285	4	0.5	6.4	1.2	-6.4	1	2
562	143	142	0.7	0.2	0.4	93190	1326	-1	0.1	7.1	-1.6	-8.7	1	0
566	127	126	1.4	1.5	1.5		1485	-4	0.4	4.7	1.0	-10.6	1	0
582	128	126	3.1	2.1	2.4	88188	1143	6	0.6	6.2	0.5	-0.5	2	-3
598	127	127	2.3	1.8	2.0		983	-1	0.5	6.0	-3.3	5.7	0	2
617	143	141	1.2	2.0	1.6		1235	8	0.4	4.4	-1.5	-5.5	2	0
619	146	146	2.6	2.5	2.6		1051	4	0.6	5.6	-1.1	2.8	0	0
659	123	123	5.2	2.5	3.8		924	9	1.1	6.0	-4.4	2.8	0	2
671	141	145	2.6	4.6	3.8	108600	1104	10	0.9	5.3	2.5	-0.2	-4	3
690	145	149	0.5	0.9	0.7		1416	6	0.2	3.0	-1.0	-9.3	-4	0
723	146	147	0.3	0.6	0.4	111234	1310	7	0.1	5.0	0.3	-5.3	-1	7
737	133	135	0.5	2.2	1.8	84423	1248	0	0.5	3.5	-2.1	-2.5	-2	11
745	124	124	1.5	1.2	1.4	82175	1220	10	0.4	5.0	-0.3	0.8	0	9
762	152	153	1.9	3.7	2.8	86634	678	-3	0.6	7.0	-0.4	-11.9	-1	7
775	137	132	2.3	1.4	1.9	109934	1143	4	0.5	4.5	-1.9	1.3	5	8
784	131	129	6.1	2.5	4.3	84815	808	3	1.1	4.5	-4.7	2.2	2	6

LANDING DATA MODEL DOUGLAS DC-9 AIRCRAFT (Continued)
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
805	125	123	1.0	1.5	1.2	81890	1371	4	0.3	5.2	-0.2	-7.1	2	8
825	123	121	2.8	3.1	2.9	78804	1405	7	0.8	6.5	1.7	-8.2	2	5
855	142	136	4.1	2.1	3.1	94160	898	3	0.8	6.7	-3.6	-2.8	6	10
856	137	135	0.9	2.2	1.5	81700	1478	-4	0.4	5.2	0.0	-11.4	2	7
897	148	145	7.2	6.5	6.8	92300	953	0	1.6	6.0	-4.4	-6.9	3	5
907	145	142	3.7	2.7	3.2		1082	-6	0.8	3.9	-4.0	-12.0	3	4
908	137	138	3.3	4.9	4.0	83220	864	4	1.0	4.8	-2.7	-4.5	-1	6
931	143	140	4.8	3.1	4.1	90924	866	0	1.0	4.5	-6.9	-2.1	3	7
937	125	121	1.2	4.1	2.1	80022	1107	9	0.6	1.6	-2.3	5.2	3	7
943	134	131	4.1	4.2	4.1	107100	1076	7	1.1	4.9	0.0	3.5	3	5
947	145	142	1.3	0.9	1.1	82495	1267	6	0.3	5.6	0.9	-4.0	3	4
965	126	122	3.4	2.9	3.1	83475	1182	5	0.9	4.0	-2.1	1.7	4	5
977	147	146	2.6	1.1	2.2	125965	1257	4	0.5	4.2	-3.1	-4.4	2	5
1059	145	145	4.5	4.9	4.7		975	3	1.1	5.4	-5.4	-10.3	0	4
1060	119	119	4.0	5.5	4.8	91092	863	8	1.4	3.3	-5.6	-8.1	0	4
1070	133	133	2.5	3.0	2.8	81065	1123	3	0.7	4.5	-1.8	3.3	0	4

LANDING DATA MODEL FOKKER F-28 AIRCRAFT
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
339	120	120	1.4	0.6	1.0		1255	0	0.3	7.8	0.9	-9.9	0	8
439	120	118	3.4	3.7	3.5	60930	760	4	1	3.5	2.1	11	2	7
936	128	125	3.1	1.4	3.1	58595	943	2	0.8	3.7	-5.7	-3.9	4	6

LANDING DATA MODEL FOKKER F-100 AIRCRAFT
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
3	149	144	4.5	5.9	5.2		724	1	1.2	4.4	-4.6	-0.2	6	4
103	128	124	1.9	2.8	2.4	73920	854	4	0.6	3.1	-3.5	-4.0	4	7
153	120	119	1.5	3.1	2.3	77440	1187	4	0.7	4.4	0.3	-0.5	2	7
171	112	113	1.6	2.4	1.8		1088	13	0.5	5.1	3.1	3.5	-1	8
358	100	98	3.1	3.4	3.8	88525	843	6	1.3	4.6	-3.2	-2.3	3	11
372	139	136	0.6	0.4	0.5	75815	1278	0	0.1	3.8	-0.5	-2.4	3	11
497	131	127	1.4	2	1.7	80131	1095	10	0.4	4.2	-1.3	-4.7	4	0
573	140	139	3.2	1.5	2.3	86026	1169	12	0.6	4.8	0.0	-3.5	1	-1
649	134	134	2.1	2.8	2.5		1512	-9	0.6	4.9	-2.1	-13.7	0	1
721	112	111	3.1	3.2	3.1	82920	763	2	1.0	3.9	-4.4	2.8	1	8
864	138	135	0.5	0.2	0.3	75835	1313	3	0.0	1.9	-0.8	-3.4	3	5
882	133	133	2.9	2.9	2.9	73835	941	4	0.7	3.8	-4.6	-4.7	0	4
986	96	91	5.5	3.8	4.4	81625	746	8	1.7	4.6	-5.3	9.6	5	9
1046	126	123	0.3	0.5	0.4	78381	1330	4	-0.1	4.0	-1.3	-5.7	3	5

LANDING DATA MODEL MD-80 AIRCRAFT
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
23	131	127	1.0	2.0	1.6	120340	1212	0	0.4	5.3	2.5	0.1	4	7
43	136	137	2.3	2.8	2.5	112000	1326	4	0.6	8.4	1.2	-6.6	-1	9
55	130	127	2.2	2.4	2.3	104769	1036	12	0.6	3.7	1.0	0.5	4	6
64	132	129	3.0	3.3	3.2	111000	1010	5	0.8	3.9	1.5	2.1	2	9
67	134	134	3.5	3.2	3.2		849	11	0.8	7.9	-7.0	-2.0	0	7
78	137	133	1.6	2.1	1.9	110300	1077	6	0.5	4.1	1.7	1.4	4	5
85	137	131	1.6	2.3	1.8	120000	1304	5	0.5	5.6	-2.2	-1.4	6	8
92	140	138	4.1	3.8	3.9	102000	1939	-3	1.0	5.1	1.5	11.8	2	8
104	119	116	2.0	3.0	2.5	101914	1040	6	0.7	4.1	0.4	4.0	3	8
106	141	141	3.0	5.7	4.3	91940	1011	2	1.0	4.1	-5.4	-8.3	1	4
120	123	119	1.9	1.9	1.9	109000	1152	0	0.5	5.7	-0.3	3.0	4	6

LANDING DATA MODEL MD-80 AIRCRAFT (Continued)
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
123	141	137	0.3	1.5	0.9	108400	1403	5	0.2	5.2	1.6	-8.5	4	7
140	150	150	2.2	1.9	2.0	107244	1213	6	0.5	5.0	1.4	-1.5	0	5
144	147	146	0.2	0.4	0.3		1438	1	0.1	8.1	0.7	-13.2	1	9
148	131	130	2.2	2.5	2.3	109000	1235	1	0.6	5.4	0.8	-5.2	1	6
150	139	138	1.1	1.8	1.4	110000	1128	10	0.4	4.3	0.9	-1.5	2	9
156	153	149	3.0	2.2	2.6	108500	943	3	0.6	4.8	-4.1	-2.7	4	6
168	134	130	2.4	2.7	2.6	107965	1168	7	0.7	6.8	1.3	-0.6	4	8
178	132	129	1.8	2.4	2.1	109991	1138	10	0.6	5.6	1.9	-4.0	4	6
179	142	138	2.5	2.5	2.3	106000	1085	5	0.6	5.7	1.7	0.0	4	9
182	138	133	3.5	4.1	3.8	123000	972	13	1.0	6.1	0.1	4.0	4	5
191	145	142	3.4	2.1	2.8	114500	949	-1	0.7	4.2	-3.2	-7.6	3	8
193	143	142	1.3	1.0	1.2	126289	1199	-6	0.3	3.9	-0.7	1.4	2	10
195	126	123	4.6	3.8	4.0	124500	1067	-4	1.1	6.4	-2.8	1.6	3	10
200	123	120	2.3	1.8	1.6		1098	7	0.5	6.0	1.5	1.2	3	10
205	133	129	1.9	2.1	2.0	121000	1114	10	0.5	4.6	1.7	1.8	4	9
222	125	124	1.1	4.6	2.9	101640	779	10	0.8	3.6	-1.8	-6.2	2	10
230	150	147	4.2	4.2	4.2	115000	972	2	1.0	5.9	-3.6	-8.2	3	8
239	140	139	4.3	5.0	4.5	122000	833	5	1.1	5.1	1.6	4.5	1	9
241	151	149	1.7	1.3	1.5	124500	1395	-5	0.3	7.6	-1.0	-8.9	2	9
244	151	149	2.9	3.4	3.2		784	8	0.7	3.9	-4.6	-1.2	2	12
250	129	131	2.4	3.1	2.8	93675	1035	8	0.7	3.6	1.3	3.0	-2	10
251	133	133	2.5	1.4	2.3	101640	1121	2	0.6	4.0	-2.6	0.9	0	10
260	132	133	0.7	0.4	0.6		1288	0	0.1	5.1	-0.1	-2.2	-2	9
284	151	146	3.9	4.0	3.9	106143	740	12	0.9	3.6	-5.5	-1.3	5	6
286	125	122	4.9	4.7	4.8	111105	788	2	1.3	5.7	-5.0	-0.3	3	9
287	151	148	3.4	4.9	4.6	105337	839	6	1.0	3.8	-2.7	-1.5	3	8
305	142	138	4.5	4.7	4.6	128100	836	5	1.1	4.2	-4.3	-4.1	4	6
310	126	122	1.7	1.7	1.7	107883	1171	1	0.5	4.3	-0.6	0.0	5	8
322	128	123	5.6	5.3	5.5	112939	795	4	1.5	4.3	-0.8	-2.1	5	8
328	140	136	4.2	4.4	4.3	127700	796	5	1.1	3.9	-2.3	-4.2	5	8
331	133	128	1.6	0.6	1.1	110965	1237	4	0.3	4.4	-0.3	-2.6	6	7
334	134	131	4.9	4.5	4.7	112000	754	7	1.2	4.4	-3.3	0.2	4	6
335	143	138	3.6	4.7	4.1	107206	957	6	1.0	4.3	-4.9	-6.0	5	6
369	136	132	4.5	4.4	4.5	101631	944	-2	1.2	4.7	-1.6	-9.5	4	11
374	154	150	2.2	2.0	2.1	128000	1984	-1	0.5	4.1	0.1	10.2	4	7
379	147	141	1.2	0.3	1.0	110673	1335	5	0.2	4.2	-2.3	-9.2	6	10

LANDING DATA MODEL MD-80 AIRCRAFT (Continued)
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
388	150	144	4.2	4.5	4.3	137190	966	-6	1.0	3.5	-4.0	-10.2	6	10
409	142	136	1.4	1.0	1.3		1210	9	0.3	4.5	1.6	-3.1	6	7
418	145	141	1.4	1.2	1.3	120030	1484	-7	0.3	6.2	-1.1	-14.4	4	6
420	131	127	1.4	1.0	1.2	108700	1371	3	0.3	7.6	-0.8	-5.5	4	7
424	139	133	1.8	1.9	1.9	126000	1334	-8	0.5	5.4	0.5	-5.1	5	7
431	140	135	2.4	2.8	2.6	109729	1010	1	0.6	2.8	-2.0	3.7	5	8
445	150	142	0.0	0.5	0.3	120000	1353	-5	-0.1	5.0	-0.5	-8.9	8	6
454	133	127	2.8	3.8	3.3	118031	1073	2	0.9	5.0	1.3	-0.5	6	8
456	139	137	4.9	5.3	5.0	120200	966	3	1.2	6.7	0.8	2.5	3	4
466	156	152	2.5	1.4	1.9	104065	875	1	0.4	5.5	-1.7	1.0	3	4
468	158	153	1.5	3.0	2.3	121310	792	2	0.5	4.7	-3.3	-3.0	5	7
476	147	144	1.0	1.9	1.5	123400	1392	3	0.3	4.8	0.6	-8.9	3	5
477	139	130	2.5	5.2	3.8	109292	634	6	1.0	5.3	-5.3	0.8	9	5
494	123	118	3.7	2.8	3.4	126000	1037	5	1.0	6.1	-2.6	4.4	5	5
511	145	144	4.3	5.2	4.4	104862	990	0	1.0	2.2	-6.0	-10.5	1	0
534	159	156	0.2	0.8	0.5	140830	1316	4	0.1	7.5	0.3	-6.3	3	0
535	139	136	2.8	2.3	2.5	104746	1248	2	0.6	4.5	0.0	-6.6	3	0
544	133	135	2.2	2.6	2.4	118771	1126	4	0.6	4.4	-0.6	0.0	-2	1
553	151	152	1.2	1.5	1.3	110000	1062	-4	0.3	5.8	-5.3	-14.5	-1	2
563	120	120	1.5	1.6	1.6	92400	1029	7	0.4	4.8	0.9	0.2	0	1
574	128	126	2.9	2.6	2.8	118799	1291	0	0.7	7.9	-0.9	-7.1	2	-3
581	139	141	6.9	3.4	4.6	96200	1036	-1	1.1	4.2	-1.6	-4.4	-2	0
595	150	149	1.2	0.7	1.0	135220	1479	-4	0.2	5.1	-0.8	-13.2	2	1
604	126	128	5.7	4.7	5.1	120000	1057	4	1.4	4.4	-3.1	3.3	-2	1
613	147	145	2.3	1.5	1.9	142600	1171	6	0.4	5.8	0.5	-4.0	2	1
620	165	163	8.9	8.0	7.8	103111	963	2	1.6	6.7	-7.2	-9.4	2	0
622	152	151	1.2	0.2	0.7	136920	1460	-6	0.2	5.1	0.9	-13.3	2	-1
633	158	157	7.1	4.4	5.8	112989	905	6	1.2	4.5	-7.1	-6.3	1	1
662	142	140	2.0	2.2	2.1	132780	1140	3	0.5	6.3	0.0	-2.2	2	3
664	127	130	4.0	2.9	3.5	127137	1195	3	0.9	8.7	-0.8	-3.5	-3	5
665	159	160	0.8	0.5	0.7	120779	1322	6	0.1	5.9	1.4	-7.1	-1	2
669	119	123	4.0	4.7	4.4	122963	1033	5	1.2	7.7	-0.2	2.4	-4	3
677	153	154	0.4	0.6	0.5		1467	0	0.1	4.2	-1.4	-10.8	-1	3
678	133	133	1.3	0.6	1.0	125280	1454	4	0.2	5.4	-0.2	-11.1	-1	3
683	139	142	1.2	1.5	1.4		1363	5	0.3	5.8	-1.3	-7.5	-3	0
689	136	139	4.3	3.7	4.0		833	-1	1.0	3.8	-4.1	-6.1	-3	0

LANDING DATA MODEL MD-80 AIRCRAFT (Continued)
FAA SURVEY WASHINGTON NATIONAL AIRPORT

Lndg. No.	Power Approach Airspeed (knots)	Closure Speed (knots)	Sinking Speed at Touchdown			Weight (lbs)	Ramp to TD Distance (ft)	Runway Off Center (ft)	Glide Slope Angle TD (degree)	Pitch Angle TD (degree)	Roll Angle TD (degree)	Yaw Angle TD (degree)	Wind Par. (knots)	Wind Perp. (knots)
			Port (fps)	Stbd. (fps)	Avg. (fps)									
709	145	149	1.9	2.0	1.9	106000	1329	0	0.4	5.9	-0.6	-8.3	-4	1
734	122	122	2.9	2.8	3.1	120066	1151	8	0.9	8.1	1.5	0.3	0	8
738	123	124	7.8	5.0	6.4	116153	808	4	1.8	5.8	-3.4	0.2	-1	9
739	138	139	4.3	3.9	4.8	110667	866	8	1.2	9.5	-6.3	-5.1	-1	6
744	149	150	0.2	0.1	0.2	133320	1395	0	0.0	7.0	1.6	-7.0	-2	9
764	149	151	3.5	1.9	2.6		1248	-4	0.6	4.6	1.3	-6.0	-2	10
786	130	127	2.5	2.7	2.6	115716	1337	0	0.7	8.2	-0.6	-3.9	3	6
795	133	130	2.4	2.5	2.5	115933	1414	6	0.6	5.3	1.0	-9.5	3	9
822	137	133	1.8	3.0	2.4		1301	2	0.6	6.7	-0.3	-3.2	4	6
829	146	144	4.6	3.9	4.2	101992	1065	-5	1.0	3.6	-4.1	-14.2	2	5
840	138	134	1.2	2.2	1.7		1452	-5	0.4	6.3	2.0	-13.3	4	5
848	126	123	3.2	2.0	2.7	111330	1229	4	0.8	4.3	-4.3	-1.1	3	5
861	151	148	2.0	2.3	2.2		1344	1	0.5	4.2	0.3	-7.0	3	5
865	139	136	2.1	2.0	2.0	118426	1263	5	0.5	5.2	0.4	-4.8	2	7
872	147	146	1.8	2.3	2.1	108768	1372	4	0.5	5.2	0.5	-8.9	1	4
883	122	119	2.5	1.9	2.2	103617	1168	6	0.6	4.3	-0.4	-0.1	3	4
889	133	131	1.5	2.6	2.1	101338	1459	-2	0.5	8.5	0.4	-11.8	2	5
894	142	138	0.9	0.0	0.5	92430	1277	6	0.1	5.5	0.4	-5.2	4	8
912	130	129	1.9	0.3	1.1		1268	4	0.3	4.1	-0.1	-3.5	1	6
921	136	133	0.6	2.9	2.0	101338	1002	8	0.5	4.0	2.4	0.8	3	6
929	144	140	0.4	0.3	0.6	112000	1158	5	0.1	5.2	-1.9	2.2	5	7
938	149	148	4.0	6.1	5.3		987	0	1.2	5.9	-3.1	-10.6	1	7
950	137	136	3.5	3.0	3.3	112075	825	3	0.8	3.9	-4.7	-1.3	1	4
972	139	137	0.1	0.6	0.4		1274	4	0.1	6.9	-0.3	-4.8	3	6
983	149	145	1.1	1.5	1.1		1324	0	0.3	3.8	0.3	-5.9	3	5
984	133	128	2.0	1.2	1.6	118947	1246	1	0.4	6.0	-0.6	-1.8	5	5
987	130	126	2.8	1.8	2.5	98760	1041	6	0.7	5.2	-2.5	3.8	4	7
1004	149	145	0.1	0.4	0.3		1414	6	0.1	4.8	0.7	-10.7	4	5
1008	124	122	1.5	2.8	2.5	125308	1160	5	0.7	4.0	1.8	0.4	3	4
1012	150	151	6.5	6.7	6.6		997	1	1.5	8.5	-4.2	-9.1	-1	6
1019	141	142	0.2	0.0	0.1		1214	7	0.0	4.9	0.7	-0.6	-1	5
1037	148	149	0.4	1.0	0.7		1276	2	0.2	5.7	-0.8	-6.1	-1	2
1040	157	155	4.2	4.2	4.2	114000	977	-3	0.9	3.5	-3.1	-10.0	1	5
1043	154	150	0.4	0.8	0.6	123390	1381	-6	0.1	6.5	-0.7	-8.6	4	3
1062	138	139	1.2	1.0	1.1	107454	1413	3	0.3	6.2	-1.1	-7.6	-1	7

APPENDIX C—LANDING PARAMETER SURVEY DEFINITIONS

AIRCRAFT INSTANTANEOUS GLIDESLOPE ANGLE β_{V_V}—This angle is determined just prior to first main wheel touchdown and is reported in degrees. The value of average sink speed (V_{V_A}) and closure speed (Vc) are used to define the instantaneous glide slope. These values are entered into the equation

$$\beta_{v_v} = \arctan\left(\frac{V_{V_A}}{Vc}\right)$$

NOTE: A consistent set of units (ft/sec) must be used in this equation.

AIRCRAFT OFF-CENTER LINE DISTANCE Y—The aircraft off-center line distance is the perpendicular distance measured between the aircraft center line and the center line of the runway. This value is calculated from image data just prior to first main wheel touchdown. Positive values of this quantify indicate that the aircraft landed on the port side of the runway center line and is reported in feet.

AIRCRAFT PITCH ANGLE θ_p —The aircraft pitch angle is measured between the aircraft reference line and a line parallel to the runway. Positive values of pitch angle are reported for an aircraft with a nose up attitude. Pitch angle is determined from image data and is reported in degrees.

AIRCRAFT PITCH RATE $\dot{\theta}_p$ —The aircraft pitch rate is calculated from image data. It is reported just prior to the touchdown of the first main wheel. Positive values of this variable indicate that the aircraft nose is pitching down. This rate is determined with respect to the runway and is reported in degrees per second (deg/sec).

AIRCRAFT ROLL ANGLE θ_r —The aircraft roll angle measured between the aircraft reference line and a line parallel to the runway. Positive values of roll angle are reported for an aircraft whose starboard wing is down. Roll angle is determined from image data and is reported in degrees.

AIRCRAFT ROLL RATE $\dot{\theta}_r$ —The aircraft roll rate is calculated from image data. It is reported just prior to the touchdown of the first main wheel. Positive values of this variable indicate that the aircraft is rolling to port. This rate is determined with respect to the runway and is reported in degrees and is reported in degrees per second (deg/sec).

AIRCRAFT YAW ANGLE YAW_{td}—The yaw angle is the angle between the aircraft center line and the aircraft flight path at the point of first main wheel touchdown. Positive yaw angle is defined to be that orientation where a clockwise rotation of the flight path vector causes the vector to coincide with the aircraft center line using a minimum angular rotation. Yaw angle is determined from image data and is reported in degrees.

APPROACH SPEED $V_{P'AF}$ —The value of approach speed reported is the algebraic sum of closure speed and component of wind speed parallel to the runway center line. The value of approach speed is the aircraft forward velocity with respect to the air mass and is reported in knots.

CLOSURE SPEED V_C —The closure speed is the speed determined by the change in the aircraft's range from the camera. It is reported parallel to the runway center line. Closure speed is reported with respect to the ground and is reported in knots. Closure speed is calculated from image measurements.

DISTANCE FROM RUNWAY THRESHOLD TO FIRST MAIN WHEEL TOUCHDOWN X_W —The distance between the runway threshold and the point of first main wheel touchdown is determined from image data and is reported in feet.

LANDING WEIGHT W—The landing weight reported in the survey is an estimate provided by the aircraft operators. The value of this quantity is reported in pounds

SINK SPEED V_V—The sink speed of the aircraft landing gear wheel just prior to touchdown. Sink speed is reported for each landing gear individually; that is for the port, starboard, and nose wheels just prior to individual deck contact. In addition the average sink speed of the aircraft main landing gear is calculated just prior to touchdown of the first main landing gear wheel. Sink speed is determined from image data. The symbols used to identify aircraft sink speed are as follows:

V_{V_A} - average sink speed
V_{V_S} - sink speed of the starboard main wheel
V_{V_P} - sink speed of the port main wheel

The values of aircraft sink speed are reported in feet per second (ft/sec)

WIND SPEED V_W —Wind Speed is the wind velocity measured by the survey team's instrumentation. A head wind is defined as the positive direction for the parallel component of wind speed. The perpendicular component of wind speed, the cross wind, is also reported. Wind speed is reported in knots.

LIST OF SUBSCRIPTS

P - Port
S - Starboard
N - Nose wheel
A - Average
r - Roll
p - Pitch

STATISTICAL SYMBOLS

N - Number of observations (data points)
$\bar{x}$ - Mean value of a parameter
P - Probability
S - Standard deviation of sample distribution